Sarajevo

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No 14

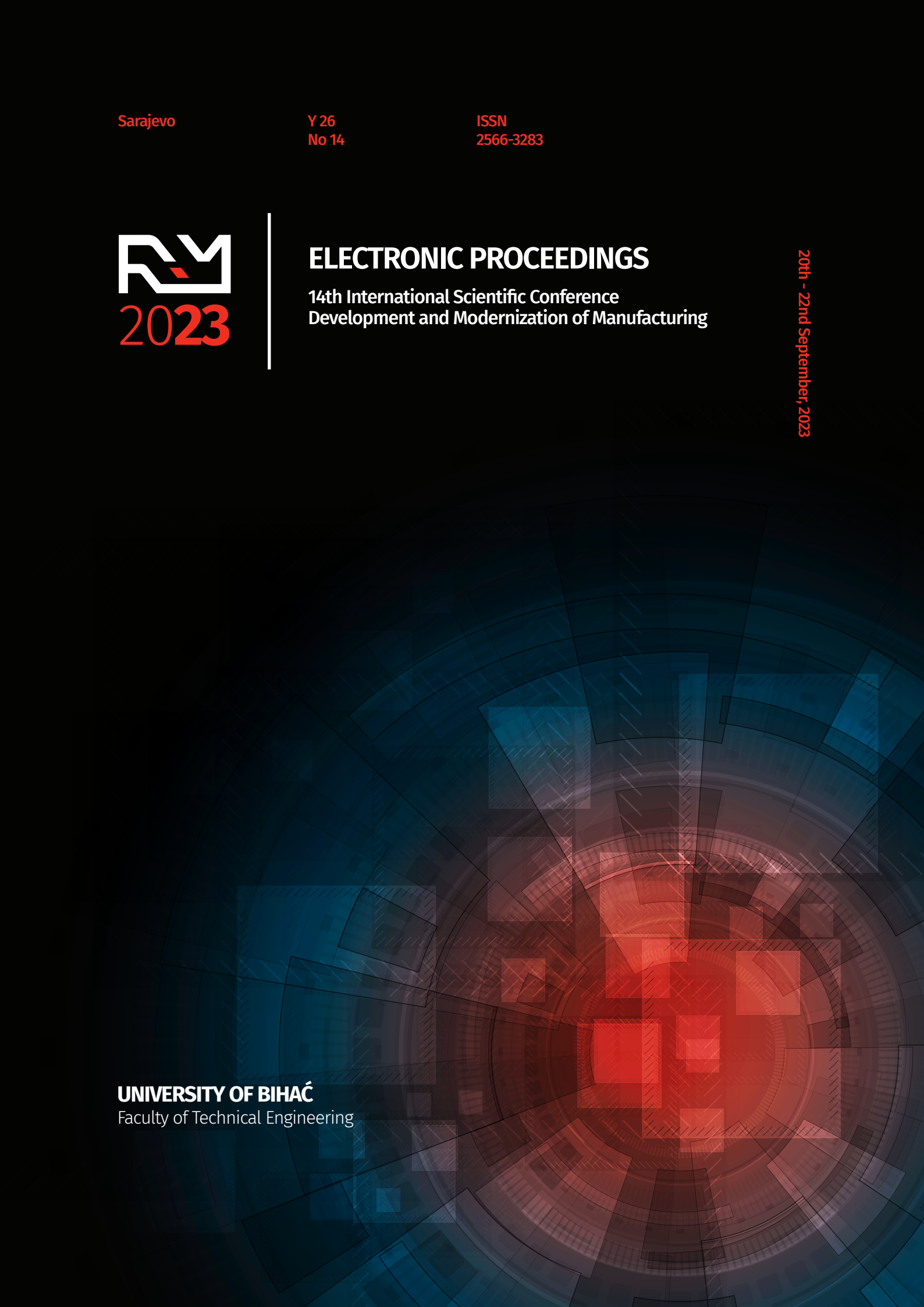
ISSN
2566-3283

RIM 2023

ELECTRONIC PROCEEDINGS

14th International Scientific Conference Development and Modernization of Manufacturing

20th - 22nd September, 2023



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Faculty of Technical Engineering

UNIVERZITET U BIHAĆU
TEHNIČKI FAKULTET

UNIVERSITY OF BIHAC
FACULTY OF TECHNICAL ENGINEERING

14th International Scientific Conference on Manufacturing Engineering
DEVELOPMENT AND MODERNIZATION OF MANUFACTURING

14. međunarodna naučna konferencija o proizvodnom inženjerstvu
RAZVOJ I MODERNIZACIJA PROIZVODNJE

RIM 2023

ELECTRONIC PROCEEDINGS

ELEKTRONSKI ZBORNIK RADOVA

20 – 22. septembar 2023.
Sarajevo, Bosna i Hercegovina

Title/Naziv:" RIM 2023 – Development and Modernization of Manufacturing"

Editors/Editori: prof.dr. Atif Hodžić, prof.dr. Damir Hodžić, prof.dr. Fadil Islamović, doc.dr. Aladin Crnkić

Publisher/Izdavač: University of Bihac, Faculty of Technical Engineering/Univerzitet u Bihaću, Tehnički fakultet

CIP – KATALOGIZACIJA U PUBLIKACIJI
NACIONALNA I UNIVERZITETSKA BIBLIOTEKA
BOSNE I HERCEGOVINE, SARAJEVO
ISSN 2566-3283

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PREDGOVOR

Opći trend razvoja i prestrukturiranja proizvodnje u tehnološki razvijenom svijetu sve se više zasniva na modernizaciji i reinženjeringu, čiji je temelj primjena novih tehnologija, fleksibilne automatizacije i organizacije, kompjuterski integrirane proizvodnje s osnovnim ciljem da se proizvodi kvalitetnije, jeftinije i brže. Na tragu tih spoznaja Naučno nastavno vijeće Mašinskog fakulteta Univerziteta u Bihaću odlučilo je da svake druge godine organizira međunarodni skup pod nazivom ***" Revitalizacija i modernizacija proizvodnje"***. Prvi skup RIM '97 organiziran je s ciljem sagledavanja i analize stanja u industriji nakon rata i stvaranja osnovnih pretpostavki za širu primjenu revitalizacije i modernizacije proizvodnje.

Međunarodni skupovi RIM održavaju se pod motom:

- Industrijska proizvodnja se realizira uz stalne i intenzivne promjene koje se sastoje u prilagođavanju novim okolnostima i zahtjevima tržišta.
- Konkurentnost i promjena strukture proizvodnje, orijentacija prema tržištu, reinžinjering i revitalizacija poslovnih i proizvodnih procesa i sistema su imperativ opstanka poduzeća.
- Revitalizacija i reinženjering proizvodnje su procesi neprekidnog inoviranja i unapređenja postojećih proizvoda, tehnologija, proizvodnih procesa i sistema od čije efikasnosti primjene ovisi opstanak proizvodno-poslovnih sistema.
- Usvajanje koncepta industrije 4.0.

Ovogodišnja četrnaesta konferencija RIM 2023 održava se pod nazivom "Razvoj i modernizacija proizvodnje" sa tematskim područjima:

A. Mašinsko inženjerstvo
B. Dizajn i tehnologija drveta
C. Elektrotehnika i računarstvo
D. Tehnologije i konstrukcije u građevinarstvu
E. Dizajn i tehnologije tekstila
F. Pravno-ekonomska regulativa i standardizacija
G. Osiguranje kvaliteta, zaštita okoliša i održivi razvoj

Na konferenciji sudjeluje 233 autora i koautora iz zemlje i inozemstva sa 123 radova. Očekuje se da će ovaj skup i prikazani radovi biti novi konkretni podsticaj i doprinos u transferu znanja i tehnologija i razvoju moderne proizvodnje, te da će ponuditi odgovore na niz pitanja kako usavršiti proizvodnju i poslovne sisteme učiniti profitabilnijim i efikasnijim na turbulentnom međunarodnom tržištu.

Svim autorima radova, suorganizatorima, pokroviteljima, institucijama i svim drugima koji su pridonijeli održavanju ove Konferencije, organizator najtoplije zahvaljuje.

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PREFACE

The general trend of development and restructuring of the manufacturing in the technologically developed world is increasingly based on modernization and reengineering, based on the application of new technologies, flexible automation and organization, computer-integrated manufacturing with the basic goal of producing better, cheaper and faster. Following these findings, the Scientific Teaching Council of the Faculty of Mechanical Engineering, University of Bihac decided to organize an international conference every second year called "Revitalization and modernization of the manufacturing". The first conference of RIM '97 was organized with the aim of reviewing and analyzing the situation in industry after the war and creating the basic preconditions for the wider application of revitalization and modernization of the manufacturing.

RIM International Conferences have been held with the motto:

- Industrial manufacturing has been realized with constant and intensive changes that consist of adapting to new circumstances and market requirements.
- Competitiveness and change of the manufacturing structure, market orientation, reengineering and revitalization of business and manufacturing processes and systems are imperative for the survival of the company.
- Revitalization and reengineering of the manufacturing are processes of continuous innovation and improvement of existing products, technologies, manufacturing processes and systems on the efficiency of which the survival of the manufacturing and business systems depends.
- Application of the concept of industry 4.0.

This year's fourteenth conference RIM 2023 is held under the title "Development and modernization of the manufacturing" with the following thematic areas:

A. Mechanical Engineering
B. Wood Design and Technologies
C. Electrical Engineering and Computer Science
D. Technologies and Structures in Civil Engineering
E. Textile Design and Technologies
F. Law-Economics regulations and standardization
G. Quality Assurance, Environment Protection and Sustainable Development

The conference is attended by 233 authors and co-authors from the country and abroad with 123 papers. It is expected that this set and presented papers will be a new concrete stimulus and contribution in the transfer of knowledge and technologies, development of the modern manufacturing and that it will offer answers to questions on how to improve the manufacturing making business systems more profitable and efficient in turbulent international market.

The organizer would like to thank all the authors, co-organizers, sponsors, institutions and all others who contributed to the organization of the Conference.

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Prof. dr. Damir Hodžić	Prof. dr. Atif Hodžić

Generalni pokrovitelj konferencije RIM 2023

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Contents/Sadržaj:

Modeling and analysis of a cartesian coordinate robot

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Abstract. In this paper is present virtual modelling and simulation of a cartesian coordinate robot for application in industrial processes. The main part of the work is the creation of a virtual model of the cartesian robot, and its subsequent analysis and simulation. The created virtual model of the cartesian robot was simulated in the Matlab software package, and it was shown how changing the basic parameters of the system has an impact on the behaviour of the cartesian coordinate robot, and on its basic characteristics: dynamic stiffness, response speed, positioning accuracy, etc. Also, it is present a physical model of cartesian coordinate robot.

1. Introduction

A robot is defined in numerous ways, according to ISO 8373, a robot is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be stationary or mobile [1]. In different ways robots can be used and applied in our daily life. The most notable aspect of this definition is that robots can be reprogrammed. The robot's capacity to be reprogrammed enables it to adapt to various situations in the proper mode and necessity of use. Robotics have been widely adopted in industry for a variety of reasons, including enhanced productivity, better accuracy, lower labor costs, greater adaptability, and better working conditions.

Figure 1. Application of robots in the automotive industry.

Robots can be categorized into generations based on the system complexity and level of intelligence. These generations include: First-generation robots (program robots) are controlled solely by their program; they lack sensors and have very little "intelligence" (apart from a memory where the program is stored). They are the most common because they satisfactorily address the handling issue in straightforward situations. Adaptive robots of the second generation are fitted with a variety of sensors and may also feature recognition systems. Third-generation robots, or intelligent robots The capacity

for learning is the most crucial factor for this artificial intelligence [2]. The robot independently responds to changes in the environment by comparing it to data collected from the outside world, or making decisions devoid of programming instructions. Regarding the workspace's geometry, robots are divided into the following categories: 1) rectangular (or cartesian) robot 2) cylindrical, 3) almost cylindrical, 4) spherical, 5) rotary (articulated), 6) scara, and 7) hexapod robot.

Figure 2. Industrial robots with regard to the geometry of the workspace.

2. Cartesian robots and their use

Industrial robots that use three linear axes to move a tool or payload in a three-dimensional Cartesian coordinate system (X, Y, and Z) are referred to as cartesian robots, also known as rectilinear or gantry robots. These robots are capable of moving along each axis separately or in tandem, enabling accurate and adaptable movements. Applications requiring a high degree of precision and repeatability, such as pick-and-place tasks, material handling, assembly, and testing, frequently make use of cartesian robots [3]. Additionally, they are used in sectors like the automotive, electronics, and pharmaceutical industries. Cartesian robots have the benefit of being able to lift heavy objects because they are frequently mounted on robust bases and can handle payloads up to several hundred kilos. Additionally, they are helpful for tasks requiring for the complex manipulation of small components due to their precise movements and capacity to fit into small spaces. As their movements are typically defined using straightforward X, Y, and Z coordinates, Cartesian robots also have the benefit of being simple to program and control. They are therefore a desirable solution for tasks requiring quick reconfiguration or frequent tool changes. However, because their movements are restricted to the three linear axes, Cartesian robots are typically less flexible than other types of robots. Additionally, they frequently cost more and are larger than other robot types, which may limit their applicability in some situations.

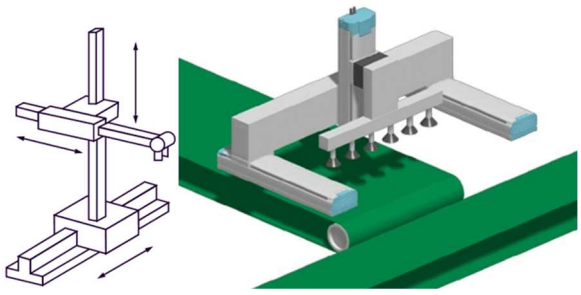


Figure 3. Configuration of Cartesian robots with 3 degrees of freedom.

3. Physical model of cartesian robot and description of robot movement system

The physical model of the cartesian robot is shown in Figure 4. This robot's manipulation area measures 500 x 500 x 100 mm. Three electromechanical linear actuators, a control system, and software support make up the Cartesian robot model. The most popular systems today for precise positioning and transport of light and large loads are electromechanical linear drives. Drive motor, coupling, threaded spindle and nut, ball bearing for spindle with housing, guides, primary support, on which the rest of the equipment is attached, and electromechanical sensor (limit switch) are all parts of electromechanical linear actuators. Rotational movement (moment) is transformed into translational movement (force) via mechanical components. A control system must be built in addition to the actuator itself.

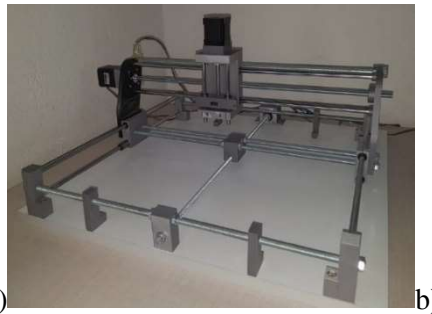
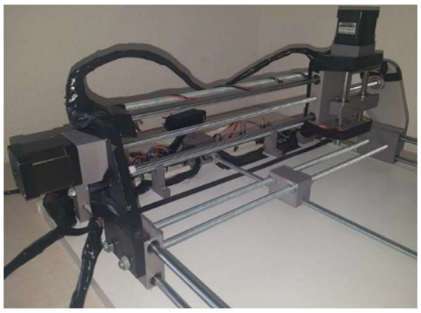
a)  b)  c) 

Figure 4. a) A physical model of a Cartesian robot; b) System for linear movement along the z axis and figure c) System for linear movement along the y axis.

A mechanism for linear movement along the z axis is shown in Figure 4a. The translator joint is the fundamental component of the system. A system of step motors and connections is used to turn the screw spindle. Together with the guides, the translator joint moves. Microswitches serve as a representation of the joint mobility limit along the z axis. They are situated 100 mm apart on the upper and lower sides. A mechanism for linear movement along the y axis is shown in Figure 4b. In addition to the system for moving along the y axis, the translator joint for moving along the y axis houses the system for moving along the z axis. Similar to the previous technique for the z axis, the nut is housed inside the translator joint. The system for linear movement down the x-axis, which functions similarly to the first two systems, is further connected to this one by rigid parts. The microcontrollers, which serve as the cartesian robot's central nervous system, are connected to the motors via control boards. In order to provide linear movement along the three axes of the cartesian coordinate system, the described model is made up of three electromechanical actuators. The developed model is a generic variation of a cartesian robot, and various attachments, such as grippers for transport and assembly procedures, tools for technological processes, or sensors for monitoring activities, can be mounted to the translator joint, depending on the task.

4. Modeling and simulation of a cartesian robot

Any cartesian robot's productivity and accuracy are heavily influenced by its own driving characteristics. A Cartesian robot needs a separate drive for each of its axes. Each linear motion system must be able to handle the mass of the components while moving them over a certain distance while maintaining linearity when it comes to load handling. Drive systems typically have a straightforward kinematic structure, but selecting the most effective actuators, mechanical transmission components, and current, speed, and position controllers is a challenge in their optimal design. All of these components must work together to meet certain requirements and have a significant impact on key robot-specific characteristics like dynamic stiffness, positioning accuracy, and movement stability. An actuator (rotary or linear), mechanical transmission components, and a cascade control of three loops (PI current control loop, PI speed control loop, and P position control loop) typically make form the drive system. The Z axis drive system's technical specifications are as follows: maximum force F_{max} of 1000 [N], total moving mass m

of 6 [kg], and leading screw spindle diameter of 8 [mm]. On a figures 5 is presented simplified model for the Z axis drive system (position and velocity loop). The models' parameters are shown in Figure 5 are: position loop gain K_v [1/s], T_s-sampling time [s], s-Laplace operator, K_p-proportional gain of the speed controller [As/rad], T_n-integral time of the controller speeds [s], T_e-time constant of the current loop [s], F-force [N], m-mass of moving elements [kg], X_i-position of input [m], X_0-position of output [m], K_m-torque constant of the rotary motor [Nm/A], K_g-constant for the transformation of linear motion into rotary motion [rad/m] ($K_g = 2\pi i/h_{sp}$). The Z-axis motion drive of the Cartesian robot uses a dual controller that consists of a PI controller for the velocity loop and a P controller for the position loop.

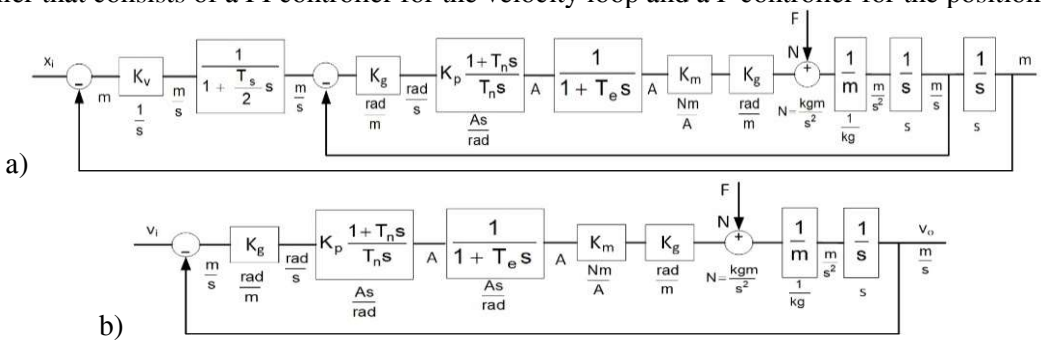


Figure 5. Simplified position loop (a) and velocity loop (b) model for a z-axis drive system.

The following equations represents the transfer function of the position loop and valocity loop for the robot motion system along the z axis:

$$\frac{x_o(s)}{x_i(s)} = \frac{b_1 \cdot s + b_0}{a_5 \cdot s^5 + a_4 \cdot s^4 + a_3 \cdot s^3 + a_2 \cdot s^2 + a_1 \cdot s + a_0} \tag{1}$$

$$\frac{v_o(s)}{v_i(s)} = \frac{b_1 \cdot s + b_0}{a_3 \cdot s^3 + a_2 \cdot s^2 + a_1 . s + a_0} \tag{2}$$

The following equation represents the transfer function of the robot's compliance for the robot's motion system along the z axis:

$$\frac{x_o(s)}{F(s)} = \frac{b_3 \cdot s^3 + b_2 \cdot s^2 + b_1 \cdot s + b_0}{a_5 \cdot s^5 + a_4 \cdot s^4 + a_3 \cdot s^3 + a_2 \cdot s^2 + a_1 \cdot s + a_0} \tag{3}$$

Figure 6 illustrate the Matlab/Simulink model that was created using the model presented in Figures 5. The position loop and velocity loop are computed using the Bode plot of the position and velocity (Figure 6) of the system moving along the z-axis that was produced by the Simulink model.

Using the models given in Figures 5, a model was created in Matlab/Simulink, given in Figure 6. With the help of the Bode plot of the position and velocity (Figure 7) of the system moving along the z axis, obtained with the Simulink model of one mass shown in Figure 6, the width of the position loop and the velocity loop are calculated. Figure 7 shows that the robot movement system along the z axis is stable according to bode diagrams.

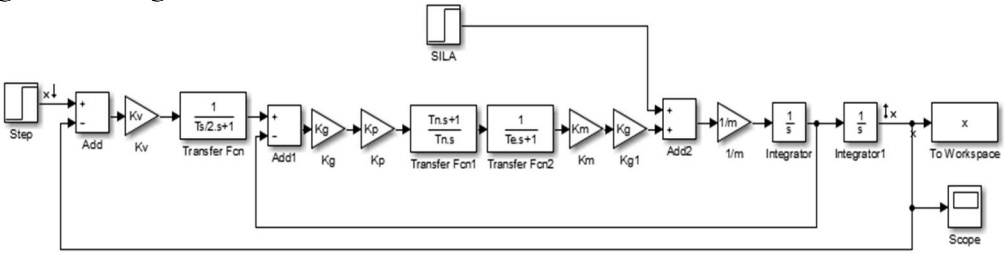


Figure 6. System model for a robot's movements along the z axis.

With the help of the model, it was possible to simulate the effects of modifying the parameters K_v, K_p, T_n, m, T_e, and T_s on the position and velocity loop. The nominal values of the parameters for the Cartesian robot's system of linear movement along the z axis are shown in Table 1. One parameter changed in the simulations while the rest were left unchanged.

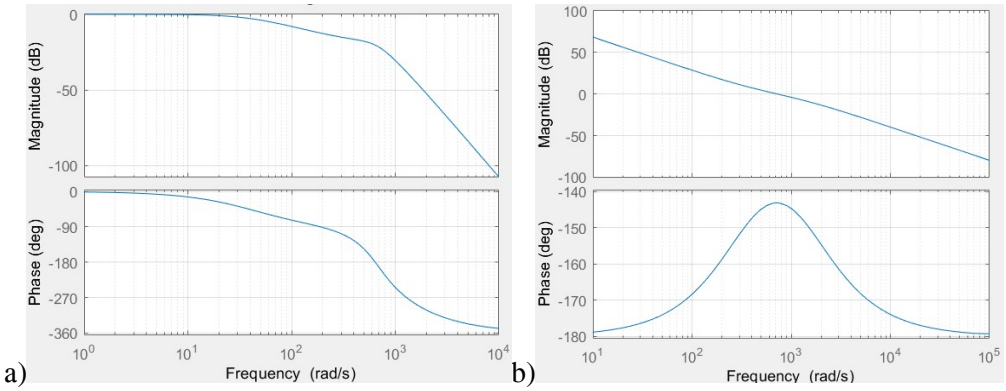


Figure 7. Bode diagrams show the robot's z-axis motion system's position (a) and velocity loop (b).

Table 1. he nominal values of the parameters for the Cartesian robot's system.

Gain of the position loop	K_v (1/s)	80	Torque constant of the rotary engine	K_m (Nm/A)	1,63
Proportional gain of the speed controller	K_p (As/rad)	0,017	Time constant of the current loop	T_e (s)	0,0007
Integral time of the speed regulator	T_n (ms)	2,8	Constant for the transformation of linear to rotary motion	K_g (rad/m)	1256
Sampling period	T_s (s)	0,002	Mass of moving elements	m(kg)	30

Figure 8a shows the system's bode diagram for various positions of the position loop gain parameter K_v. The system is stable because, in every case, the frequency of the critical amplitude is lower than the frequency of the critical phase, as can be seen from the diagram for all tested K_v values. Positive numbers for phase and amplitude reserves, another sign of system stability. The value of the amplitude reserve grows while the value of the phase reserve drops as the K_v parameter is increased. The deviation for various values of the proportionate gain of the speed loop remains the same and is within the permitted limits, according to figure 8b. This leads us to the conclusion that the system is stable regardless of how the parameter K_p changes. The positional loop stays stable in the same scenario even when the parameters T_n, m, T_e, and T_s are changed, as shown in figures 9 and 10.

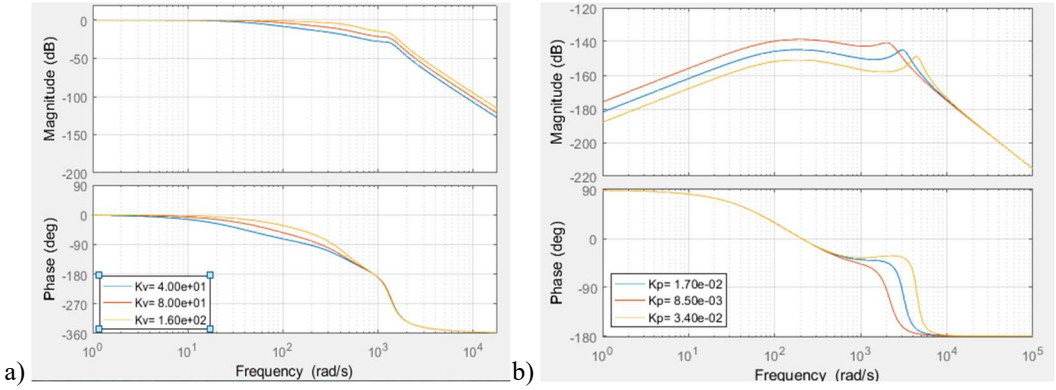


Figure 8. The impact of changing the parameter K_v (a) and parameter K_p (b) on the positional loop's width for movement along the z-axis.

The data deviation for various values of the proportional gain of the position loop remains the same and is within the allowed limits, and it is approximately 0.3%, according to diagram 11a. This leads us to the conclusion that the system is stable regardless of how the parameter K_v changes. The system can be made more stable by increasing the parameter K_p, however as can be seen from the diagram in figure 11b, the amplitude reserve of the system reduces as the parameter K_p rises.

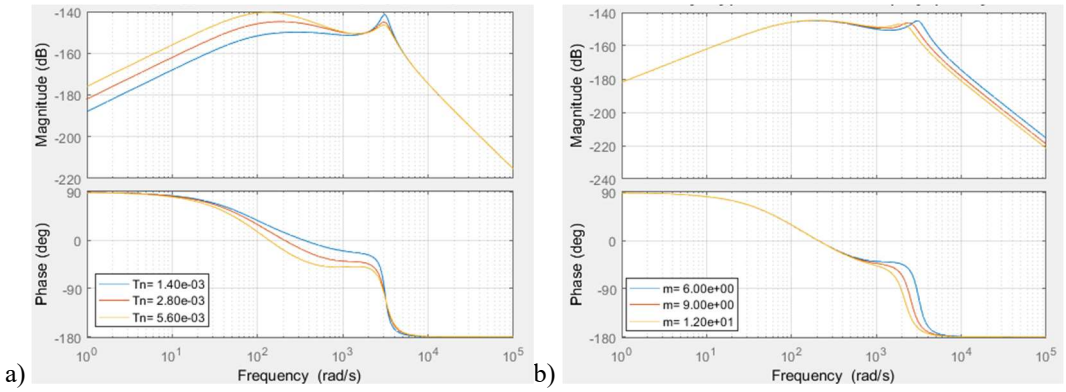


Figure 9. The impact of change in parameter T_n (a) and m (b) on the positional loop's width for movement along the z-axis.

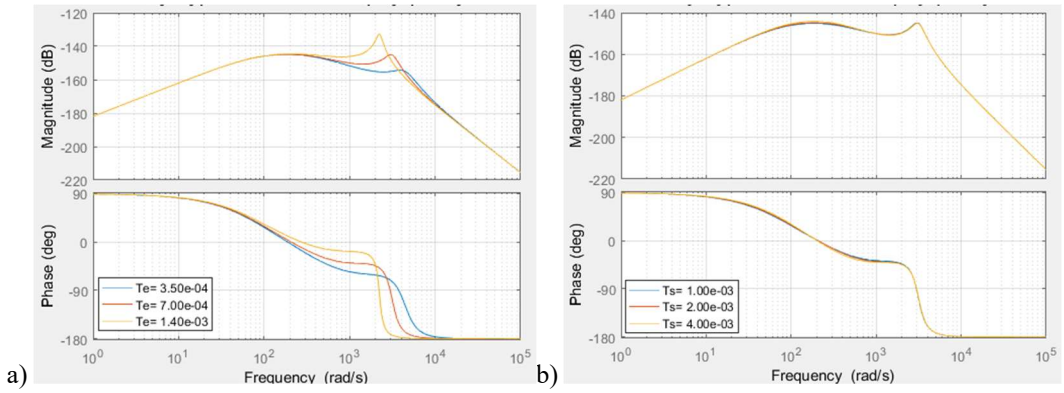


Figure 10. The impact of change in parameter T_e (a) and T_s (b) on the positional loop's width for movement along the z-axis.

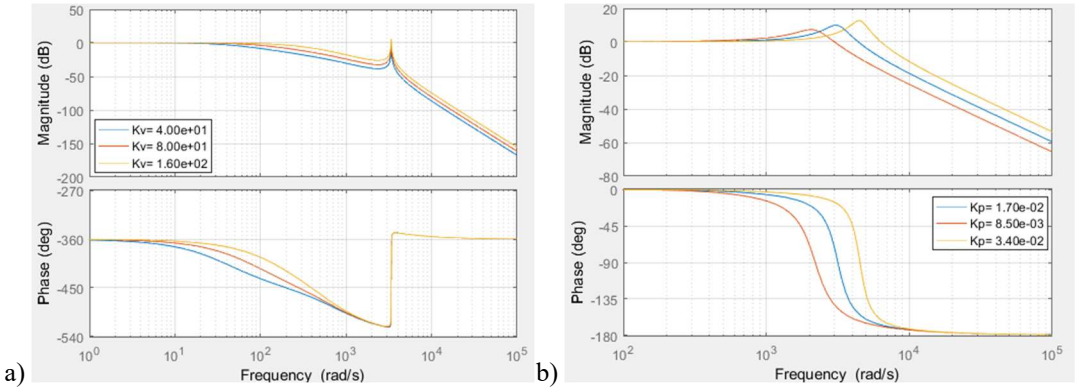


Figure 11. The influence of changing the K_p parameter on the width of the velocity loop (a) and the effect of changing the K_v parameter on the speed loop width for movement along the z axis.

The diagram from Figure 12a shows most clearly how the parameter T_n and the integral time of the speed are affected by the speed loop. The diagram shows that the system is unstable for the value T_n= 0.0028 [s] and regulation deviation is 100%, while it is within acceptable limits for the other tested values of T_n. According to the diagram (fig. 15b), the regulatory deviation for a mass of 6 [kg] is within

the acceptable ranges, however the deviation is close to 100% for other higher amounts of mass. Diagrams (figures 13a and 13b) show the same for the variation of the time constants T_e and T_s.

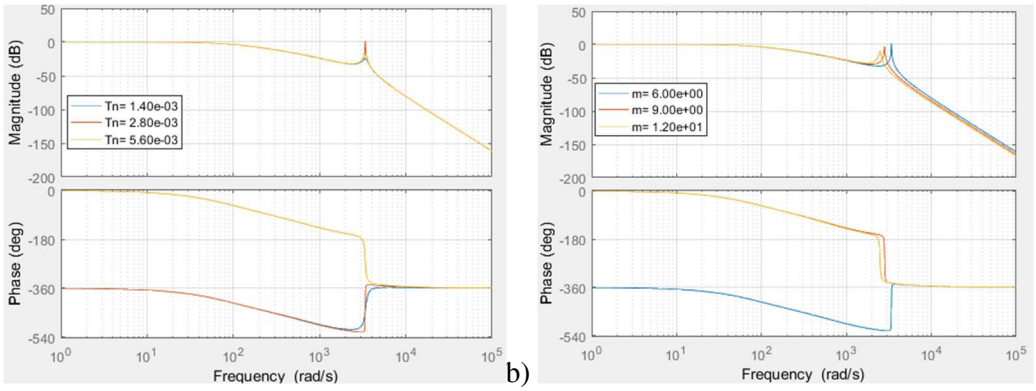


Figure 12. The impact of changing the parameter T_n (a) and m (b) on the speed loop width for movement along the z axis.

The sensitivity of linear motion systems to load changes is one of the most crucial criteria. Stiffness is a qualitative indicator of a cartesian robot system's sensitivity. A measure of the impact of disturbances F at the output position x_o (angular position) on variations in the transient period is the stiffness of the dynamic drive system.

$$S_d(s) = \frac{F(s)}{x_o(s)} = \frac{T(s)}{\Theta_o(s)} \tag{4}$$

Dynamic stiffness of the linear motion system becomes:

$$S_d(s) = \frac{F(s)}{x_o(s)} = \frac{a_5 \cdot s^5 + a_4 \cdot s^4 + a_3 \cdot s^3 + a_2 \cdot s^2 + a_1 \cdot s + a_0}{b_3 \cdot s^3 + b_2 \cdot s^2 + b_1 \cdot s + b_0} \tag{5}$$

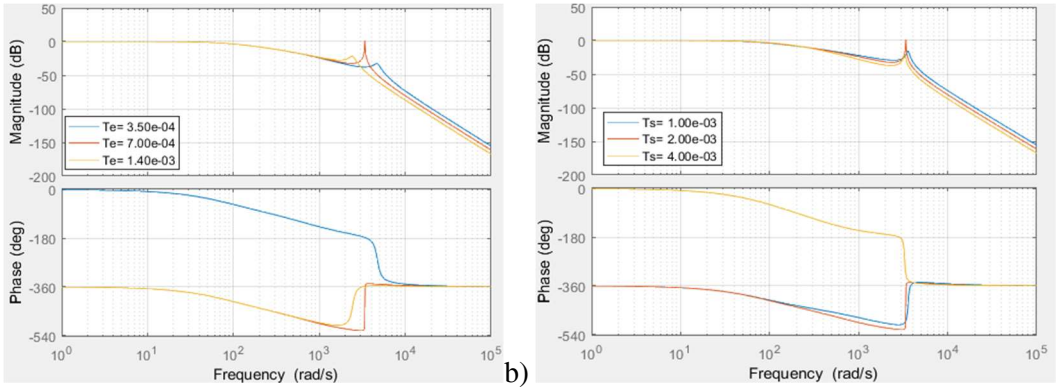


Figure 13. a) The effect of changing the Te (a) and Ts parameter (b) on the speed loop width for movement along the z axis.

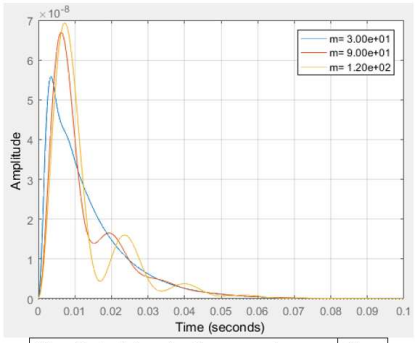
Simulation of the dynamic stiffness of the robot movement system along the z axis depending on the change in m, K_v, K_p, T_n, T_s and T_e in the time domain. The following equation is used to estimate the dynamic stiffness:

$$S_d = \frac{F}{\max X_0(t)} [N/m] \tag{6}$$

where: F is the disturbance force, and $\max X_0(t)$ is the maximum position deviation caused by the disturbance force. The disturbance force used in the simulation is F = 10 [N]. The linear motor feed transfer function and the servo dynamic stiffness complex function indicate that system is a high-order mathematical model. Figure 14a shows the displacement response under initial situations, with a moving

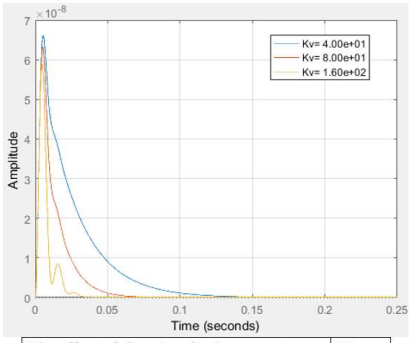
element weighing 30 to 120 [kg]. This shows that if the mass of the moving part is smaller, the system's response speed and dynamic stiffness are higher. As the mass of the moving part increases, the servo dynamic stiffness of system decreases and the frequency of oscillations rises. Additionally, adjustment times lengthen and the system has a tendency to skip, which has a significant impact on the accuracy of the moving parts themselves. Displacement response is shown in Fig. 14b with corresponding position loop gains from 40 to 160 [1/s]. It demonstrates that as the proportional gain of the position loop rises, the response speed increases, the servo dynamic stiffness increases, and the number of oscillations also increases. When K_v is too great, the system is at risk of instability. While the system is stable, increasing K_v can reduce steady-state error and position tracking error while also improving control accuracy. However, steady-state error cannot be completely eliminated. One crucial element of an AC servo system is the proportional gain of the position loop. It is changed based on the load and the level of positioning accuracy needed.

a)



The effect of changing the parameter m on the dynamic strength				%
m(kg)	30	90	120	400
x(nm)	56	67	70	+25
Sd(N/μm)	178,57	149,25	142,86	-20

b)

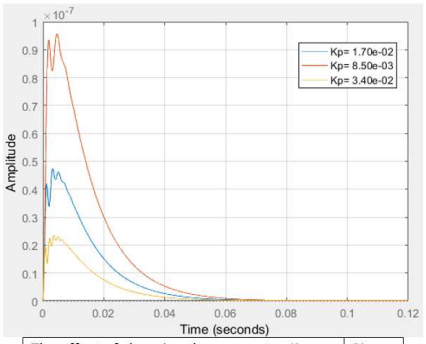


The effect of changing the K_v parameter on the dynamic strength				%
Kv(1/s)	40	80	160	400
x(nm)	66	64	61	-7,68
Sd(N/μm)	151,51	156,25	163,93	+8,20

Figure 14. a) Dynamic stiffness and the impact of mass change. b) The impact of changing the position loop's proportional gain on the dynamic stiffness.

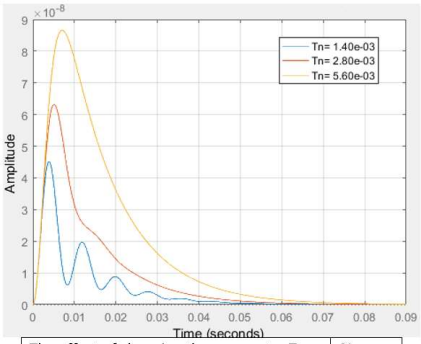
Figure 15a shows the displacement response with different proportional velocity loop increases from 0.017 to 0.034 [As/rad]. This shows that when the velocity loop proportional gain increases, the maximum output displacement at step force input drops and the servo dynamic stiffness rises. In general, the speed loop maintains a constant speed while preventing oscillations. Figure 15b illustrates the displacement response for integral velocity loop increases from 0.0014 to 0.0056 [s]. This suggests that when the integral response time of the velocity loop grows, the dynamic stiffness of the servo system decreases. When Tn is too large, the system's performance fails, and when Tn is too small, oscillations cause the system to become unstable. When the system is stable, T_n can be decreased to increase the servo-dynamic stiffness of the system. The integrated unit increases the precision of system control, ensures system steady state and transient performance, and eliminates system steady state error. It also reduces the speed variation in the load disturbance.

The filter component is used in the velocity loop to reduce its bandwidth and reduce system disruptions caused by high-frequency signals. Figure 16a illustrates the displacement response with a filtering time constant that ranges from 100 to 4000 μs. This indicates that the oscillations rise as the servo system's dynamic stiffness reduces. To improve the servo system's anti-interference capacity and control the amplitude and phase of the armature current, a current feedback section is added to the speed loop. To increase the speed of the dynamic response in the current loop, proportional gain is used. Figure 16b shows the displacement response with proportional current loop gains ranging from 0.00035 [s] to 0.0014 [s]. It also indicates that as the proportional gain of the current loop increases, it also increases the servo motor's dynamic stiffness. When the proportional gain of the current loop is too high, the accuracy and stability of the speed control as well as the variation in error of the elements reduce.



a)

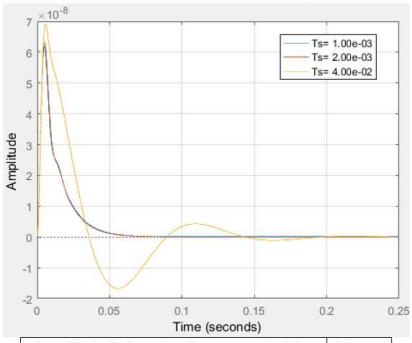
The effect of changing the parameter K_p on the dynamic strength				%
Kp(As/rad)	0,0085	0,017	0,034	400
x(nm)	96	48	24	-75
Sd(N/µm)	104,16	208,33	416,67	+400



b)

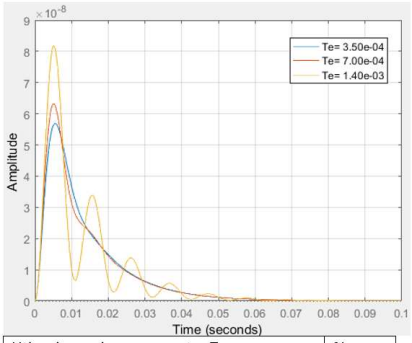
The effect of changing the parameter T_n on the dynamic strength				%
Tn(s)	0,0014	0,0028	0,0056	400
x(nm)	45	63	87	+93,33
Sd(N/µm)	222,22	158,73	114,94	-48,27

Figure 15. The effect of changing the velocity loop's proportional gain (a) and integral gain (b) on the dynamic stiffness.



a)

The effect of changing the parameter T_s on the dynamic strength				%
Ts(s)	0,001	0,002	0,004	400
x(nm)	62	64	69	+11,29
Sd(N/µm)	161,29	156,25	144,93	-10,14



b)

Utjecaj promjene parametra Te na dinamičku čvrstoću				%
Te(s)	0,00035	0,0007	0,0014	400
x(nm)	57	63	82	+43,86
Sd(N/µm)	175,43	158,73	121,95	-30,49

Figure 16. Dynamic stiffness can be affected by a variety of factors, including: a) changing the filtering time constant; and b) proportionally increasing the current loop.

5. Conclusion

Making a mathematical model and simulating a cartesian robot was the aim of this research. The simulation was done using Matlab. The simulation results for the movement of the manipulator show the dynamic performance speed and torque. Dynamic performance simulation results for changing robot variables can be modified to obtain the required dynamic parameters. Robot modeling and simulation approaches demonstrate how simple it is to make design and structural changes based on a simulated dynamic analysis. Thus, building a robot with the desired configuration will be easier and less expensive. The transfer function of the linear motor and the dynamic stiffness are both analyzed as part of the control model for the linear motor power supply system, which serves as a guide for choosing and controlling the parameters. The results of the simulation show that the integral response time of the speed loop, the proportional gain of the position loop, and the proportional gain of the speed loop are the three parameters that have the biggest impact on the dynamic stiffness of the servo motor. The proportional gain of the position loop, the proportional gain of the velocity loop, the integral response time of the velocity loop, and the dynamic stiffness all increase while the displacement response drops in response to the disturbance force step input. The system experiences fewer oscillations overall and shows a tendency toward stability. A cartesian robot's movement system can be virtually modeled and

simulated using the model that has been described. This model allows for the design, complicated performance analysis, testing, optimization, and application of various control structures in a computer simulation environment. Additionally, it makes it possible to effectively optimize the design of the cartesian robot's motion system while taking positioning accuracy, dynamic stiffness, and control dynamics into account. The creation of a virtual prototype, on which all tests will be run and further modified before manufacturing the final version itself, can replace the practice of making a highly expensive real robot prototype.

6. References

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Strength verification of non-standard piping support construction

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Abstract. One of the major requirements during piping design is to route the pipe on the way that supporting can be carried out in the simplest possible way by using standard supports. Under the term standard support means support assembled of components that are designed and verified by registered support manufacturer. But, in some cases, due to the unfavorable location of pipes, equipment and surrounding steel construction, non-standard piping supports must be used. Such non-standard supports, or some of their components, are subject to additional strength analysis to verify support structure capability. This paper presents strength verification of non-standard support designed on high pressure live steam piping system. Analysis is based on FEM calculation considering highest piping design conditions.

1. Introduction

This paper presents stress and strength verification of one non-standard support constructed on high pressure live steam system. Support construction, which is designed in SmartPlant3D CAD software and its corresponding drawing [1] are presented in figure 1. As it can be seen, support consists of several parts:

a) Constant support and connecting elements as standard LISEGA components [2],
b) Primary and secondary steel which are separately analyzed by civil engineers,
c) Connecting pipe which is commonly called stanchion and a base plate.

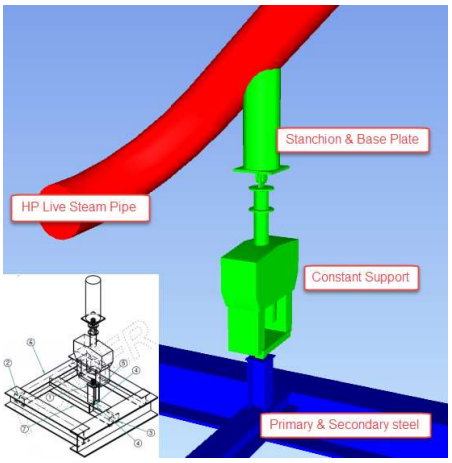

Figure 1. SmartPlant3D supports design and corresponding drawing.

The main goal of the analysis presented in this paper is verification of structural capability of stanchion and base plate and respective steam pipe area, where stanchion is attached. Analysis is based on FEM calculations by using ANSYS software. Calculation results are evaluated according to von Mises theory [3, 4] and criteria from EN 13445-3 Annex C [5].

Major design parameters for high pressure live steam pipe, as well as stanchion dimensions, are presented in table 1. Piping wall thickness and material are specified during concept engineering by considering design parameters and requirements from EN 10216-2 [6] and EN 13480-2 [7].

Table 1. Piping design parameters and stanchion dimensions.

HP live steam pipe OD x WT (mm)	Material	Maximum design pressure (bar g)	Maximum design temperature (^{0}C)	Allowable stress f (MPa)	Stanchion dimensions OD x WT (mm)
323.9 x 36	1.4903 (X10CrMoVNb9-1)	178.1	571.5	95	219.1 x 10

Stanchion and base plate are made of the same material as main steam pipe in order to satisfy material compatibility, welding procedure and heat transfer.

2. Calculation model and boundary conditions

The calculation model is based on SmartPlant3D design. Dimensions and geometry for pipe, stanchion and base plate are redesigned and meshed in ANSYS software. Approximately four meter of main pipe is included in the model. Meshed model is presented in figure 2. Mesh is generated as combinations of tetrahedral and hexahedral 3D finite elements [8]. Pipe segment close to the connection with stanchion is meshed fine, while the connected segments serve as a kind of boundary condition to ensure correct system behavior and load implementation.

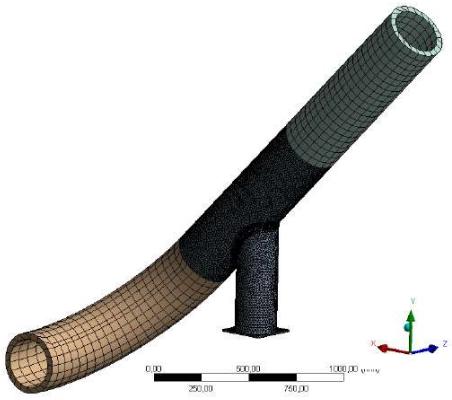

Figure 2. Meshed structure for pipe, stanchion and base plate.

The internal forces, moments and displacements of this area are exported from the pipe stress analysis [8] and implemented into the finite element model as boundary conditions to ensure a realistic behavior of the components. Pipe stress analysis [9] is performed according to EN 13480-3 [10].

Applied loads are normally related to the global coordinate system which is used in pipe stress analysis [9], while pipe segments in ANSYS get special local coordinate systems. In any case the correct relation between loads and coordinate systems is assured. As the worst case, extreme loads calculated for the lifetime of 200000 h, are taken into account.

FEM calculation model with all loads and constraints is presented on figure 3.

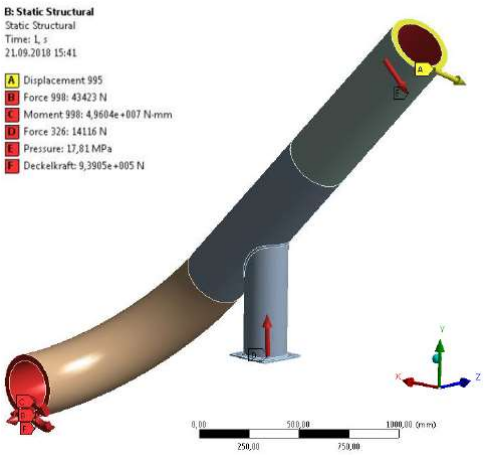

Figure 3. FEM calculation model with loads and constraints.

3. Calculation results

Figure 4 shows the equivalent calculated stresses as per von Mises [3, 4] with the legend limited to the allowable stress of 95 MPa [10]. The calculated stresses do not exceed the value for allowable stress, except for a small area close to the bend. To fulfill the requirements of EN 13445-3 Annex C [5], it is necessary to evaluate the stresses based on the stress linearization. Stress linearization is presented in Chapter 4 of this paper.

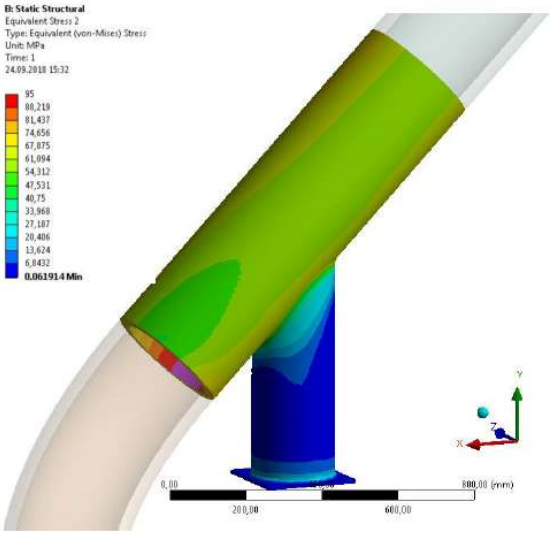

Figure 4. Equivalent calculated stresses as per von Mises (MPa).

Figure 5 shows the stresses in the base plate of the piping support. The legend is limited to the allowable stress at 300°C. Since the expected real temperature at this location is around 150°C this approach is very conservative. The maximum stress as per von Mises is 110.7 MPa and therefore far below the allowable stress of 240 MPa [10].

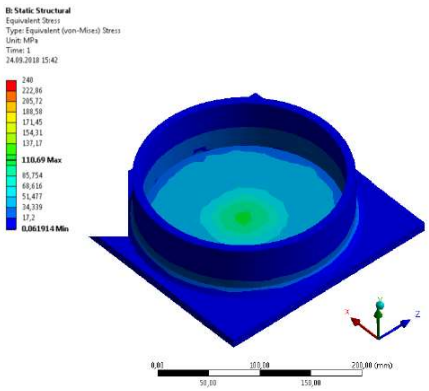

Figure 5. Base plate - equivalent calculated stresses as per von Mises (MPa).

4. Stress linearization

As it is described in Chapter 3 and presented on figure 3, calculated von Mises stresses exceed the value for allowable stress for a small area close to the bend of main steam pipe. To fulfill the requirements of EN 13445-3 Annex C [5], it is necessary to evaluate the stresses based on the stress linearization. Stress linearization is a procedure in which the stress distribution through the wall thickness is approximated with an equivalent linear stress distribution, like to what would be the result of an analysis using shell theory.

The assessment criteria are [5]:

$$\left(\sigma_{eq}\right)_{P_m} \leqslant f \tag{1}$$

$$\left(\sigma_{eq}\right)_{P} \leqslant 1.5\, f \tag{2}$$

where are:

σ_{eq} - equivalent stress
f - allowable stress = 95 MPa
P_m - primary general membrane stress calculated across the wall thickness without taking into account discontinuities and stress concentrations
P - total primary stress = $P_L + P_b$
P_L - local membrane stress calculated across the wall thickness taking into account large discontinuities, but not stress concentrations
P_b - bending stress which does not include discontinuities and stress concentrations

As it is presented in figure 6, three paths for the stress linearization are generated and analyzed.

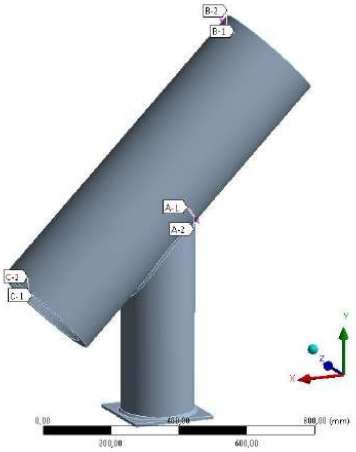

Figure 6. Paths for stress linearization.

Path A1-A2 represents the total primary stress as a sum of local membrane stress and bending stress, while paths B1-B2 and C1-C2 are located in areas of general membrane stress. By applying equations (1) and (2), stress linearization criteria are fulfilled as follows.

Path A1-A2:

$$\left(\sigma_{eq}\right)_P = 92.63 \text{ MPa} \leqslant 1.5\, f = 142.5 \text{ MPa} \tag{3}$$

Path B1-B2:

$$\left(\sigma_{eq}\right)_{P_m} = 79.84 \text{ MPa} \leqslant f = 95.0 \text{ MPa} \tag{4}$$

Path C1-C2:

$$\left(\sigma_{eq}\right)_{P_m} = 73.39 \text{ MPa} \leqslant f = 95.0 \text{ MPa} \tag{5}$$

The respective stress linearization are presented in figures 7 – 9.

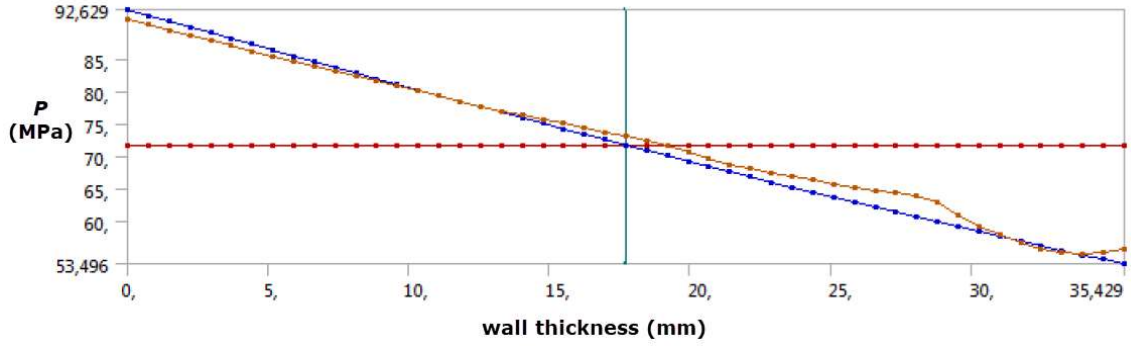

Figure 7. Path A1-A2: Linearized stress as per von Mises (MPa).

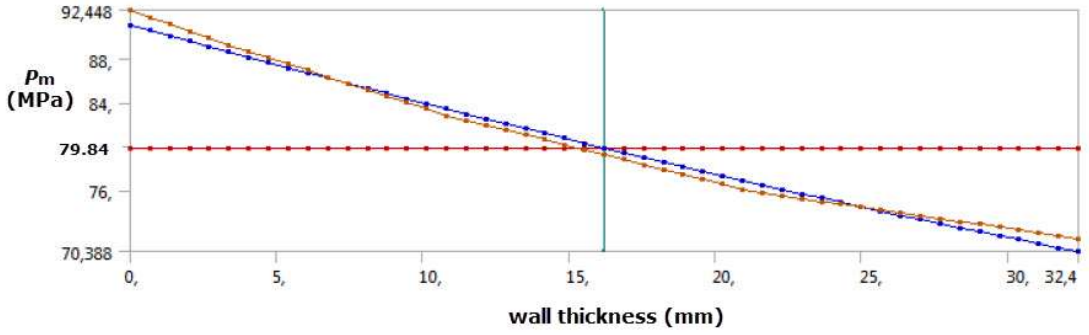

Figure 8. Path B1-B2: Linearized stress as per von Mises (MPa).

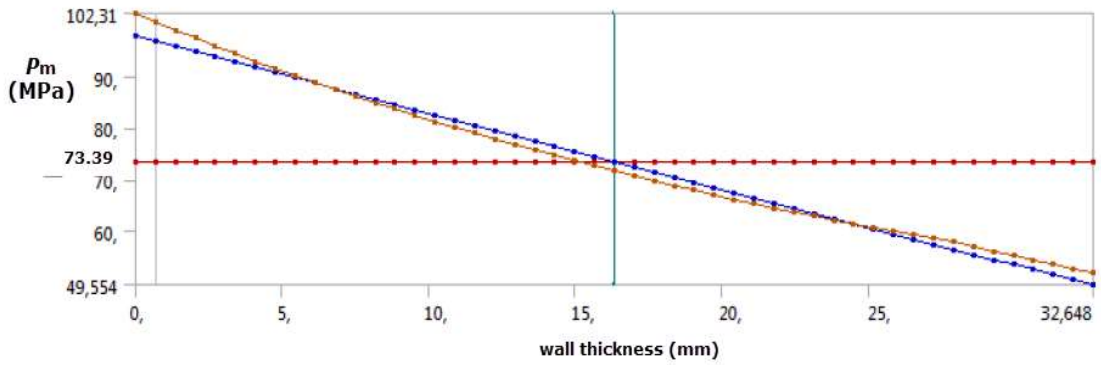

Figure 9. Path C1-C2: Linearized stress as per von Mises (MPa).

5. Conclusion

Support described in this article is, mainly due to unfavorable pipe routing, constructed on high pressure live steam piping system as non-standard support. Therefore, such non-standard support is subject to additional stress and strength analysis for the verification of support construction capability for taking over the calculated loads.

Analysis was performed by applying FEM calculation with ANSYS software and with evaluation of calculated results considering criteria from EN 13445-3.

The calculation results show that the analyzed non-standard piping support, as well as the respective pipe segment where support is attached, can withstand the given loads without any restriction. With regard to fact that extreme loads calculated for the lifetime of 200000 h are taken into account, it can be stated that the approach of these calculations is very conservative and the design therefore absolutely safe. Consequently, support construction capability for taking over the calculated loads is proved.

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Vibration in Metal Rolling Process

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Abstract. Rolling is the most widely used metal forming process. In this paper a single-degree-of-freedom vibration model for rolling process is analyzed in analogy to analysis in metal cutting process, according to research by Stépán, Moon, Insperger, Kalmár-Nagy and Hu. First it was introduced relevant terminology, geometry and the key dynamics of rolling, the pressure and rolling force as Celikov's solution Kármán's differential equation. The elastic roller with the support assembly is approximated with a simply supported beam with a lumped mass in the middle, excited by rolling force acting on mass. Celikov's solution the rolling force is too complicated and the force was approximated with a polynomial function, where the draft thickness is an independent variable. The vibration model of rolling process includes the classical regenerative effect that causes self-excited vibrations. The associated time delay is the time-period of one revolution of the rolls. The obtained mathematical model vibration in metal rolling process is a simple-second-order delay-differential equation (DDE). DDE has been solved numerically for the realistic system parameters. The numerical solution of DDE obtained stable and unstable motion, depending on the value of the time delay. Therefore, the Hopf bifurcation occurred, where the bifurcation parameter was the time delay.

1. Introduction

The process of shaping metals into semi-finished or finished forms by passing between rollers is called rolling. Rolling is the most widely used metal forming process. It is employed to convert metal ingots to simple stock members like blooms, billets, slabs, sheets, plates, strips etc. In rolling, the metal is plastically deformed by passing it between rollers rotating in opposite direction. The main objective of rolling is to decrease the thickness of the metal. Ordinarily, there is negligible increase in width, so that the decrease in thickness results in an increase in length. Rolling is performed in many different regimes but is generally categorized into hot rolling, cold rolling and foil rolling. The metal rolling process has a wide application in many industrial fields. The reason for that is a list of advantages as follows: two distinct parts can be run together to form one assembly, rolling process is an energy efficient process usually requiring no process heat to be added, - rolling process can produce superior surface finishes which often eliminates the need for additional finishing, producing parts with long lengths, and the only limitations are due to material handling equipment, space constraints, and shipping capabilities, with adequate equipment, tools, devices, and necessary process automation large quantities. [1-4]

The interaction between the metal and the roll gives rise to vibrations. Vibration in metal rolling process results in unacceptable gauge variations, affects the surface quality of rolled strip, and may damage the machine stand. One of the most important source of vibrations in a rolling process is the regenerative effect. Based on Zhao and Ehmann's and Hu's model, more complex regenerative vibration models are proposed in recent years. The present deformation and the one made one revolution earlier

might overlap, causing metal thickness (and thus rolling force) variations. The associated time delay is the time-period τ of one revolution of the rolls. Vibrations in the metal rolling process can be categorized as self-excited vibrations, or vibrations due to external sources of excitation (such as resonances of the machine structure). In this paper, only self-excited vibrations were analyzed. Self-excited vibrations occur when the forcing function is a function of the displacement, velocity or acceleration of the system mass. [5-8]

The mathematical model of vibration in metal rolling process is a Retarded Functional Differential Equations - RFDEs. Retarded Functional Differential Equation - RFDE is mathematical terminologies. In engineering RFDE called Delay-Differential Equation and abbreviation as DDE. DDEs are also called time-delay systems. The mathematical modeling of regenerative effect goes back to the 1950s, when the theory of Delay-Differential Equations started its development in mathematics. [9, 10]

2. Geometry of Rolling Metal Process

It is worth introducing relevant terminology and geometry before explaining the key dynamics of rolling. The dynamic rolling gap is shown as in figure 1, when only the vertical roll vibration is considered. Roll radius is R. v_0 and v_1 are the entry and exit workpiece velocity. h_0 and h_1 are the workpiece thickness at entry and exit. b_0 and b_1 are the workpiece width at entry and exit. v_r is the work roll linear velocity. h_n is the workpiece thickness at neutral point. Friction plays a critical role in enabling rolling. The condition for rolling is $\mathrm{tg}(\alpha) < \mu$, where is μ the friction coefficient and α the angle of contact (bite) on rolling. [3, 9]

The amount the workpiece thickness is reduced is the absolute deformation (gauge, draft):

$$\Delta h = h_0 - h_1 . \tag{1}$$

The length of contact between rolls and workpiece L, is usually much smaller than the width of the metal, b, figure 1. As the plastic region is thinned by the compressive stress, it is free to expand in the rolling direction. However lateral expansion is constrained by the undeforming material on both sides of the roll gap. On the inlet side of the gap, the roll surface is moving faster than the work material, whereas on the outlet side material moves faster than the roll surface. [11]

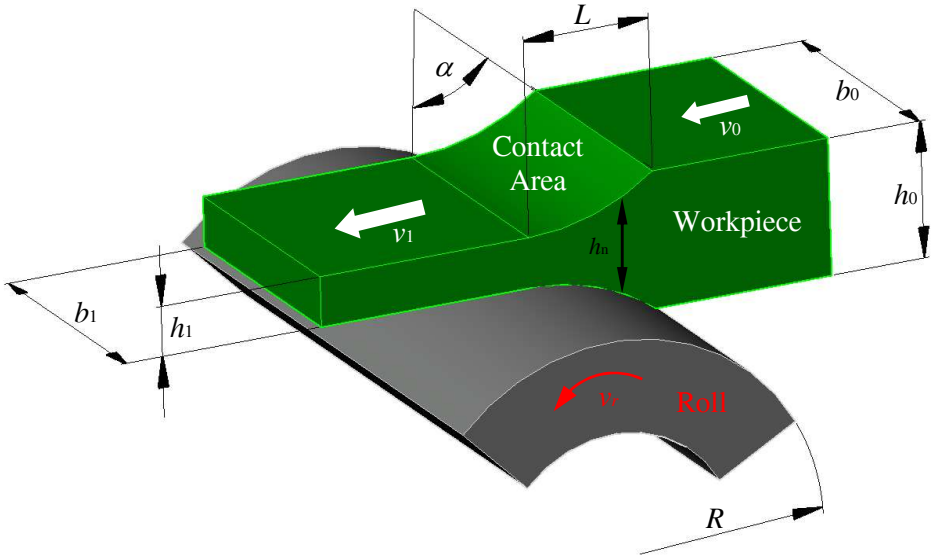


Figure 1. Geometrical model of rolling metal process.

Figure 2. shows the roll-gap geometry, where R is the roll radius, $\Delta h = h_0 - h_1$ - the equation (1) and

L is the projected contact length. It can be seen that [11]:

$$L^2 = R^2 - \left(R - \frac{\Delta h}{2}\right)^2 = R\Delta h - \frac{\Delta h}{2}.$$

Neglecting the last term, $\Delta h/2 \approx 0$:

$$L = \sqrt{R\Delta h} = \sqrt{R\varepsilon h_0}\,, \tag{2}$$

where the reduction is relative degree of deformation $\varepsilon = \Delta h / h_0$.

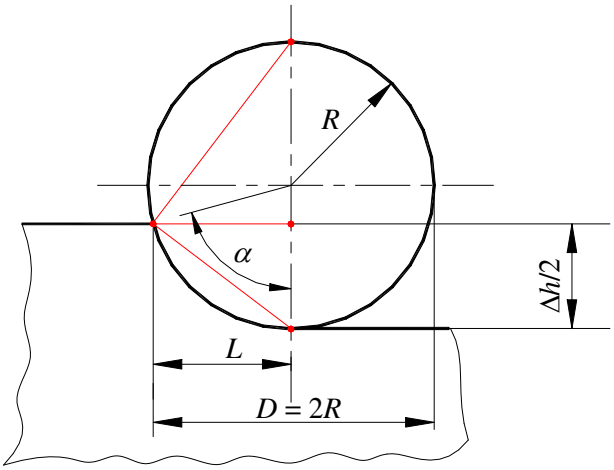


Figure 2. Geometry of the roll gap.

The projected contact area A is product of the projected contact length L and the workpiece contact width $b_{sr} = (b_0 + b_1)/2$, figure 3.

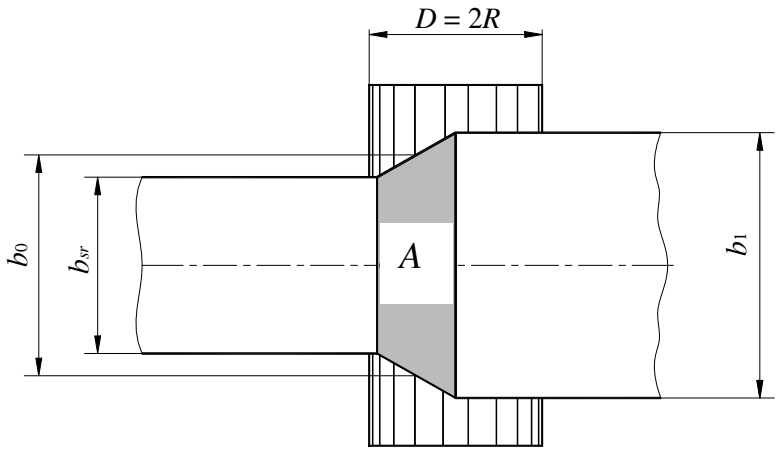


Figure 3. Projected contact area on rolling.

$$A = b_{sr} \cdot L = \frac{b_0 + b_1}{2} \cdot L = \frac{b_0 + b_1}{2} \cdot \sqrt{R\Delta h}\,. \tag{3}$$

The angle of contact is a function of the absolute deformation and the diameter of rollers:

$$\cos\alpha = 1 - \frac{\Delta h}{D}. \tag{4}$$

The sizes and their mutual relationship are shown in figure 2.

3. Pressure and Nonlinear Force of Rolling Metal Process

Dynamical model of rolling metal process is shown as in figure 4, when only the vertical roll vibration is considered. Set the coordinates x and y onto the center line of rolled piece and the work roll center line. And the intersection point is set as the origin of coordinates. σ_1 and σ_2 are the entry and exit tensile stress.

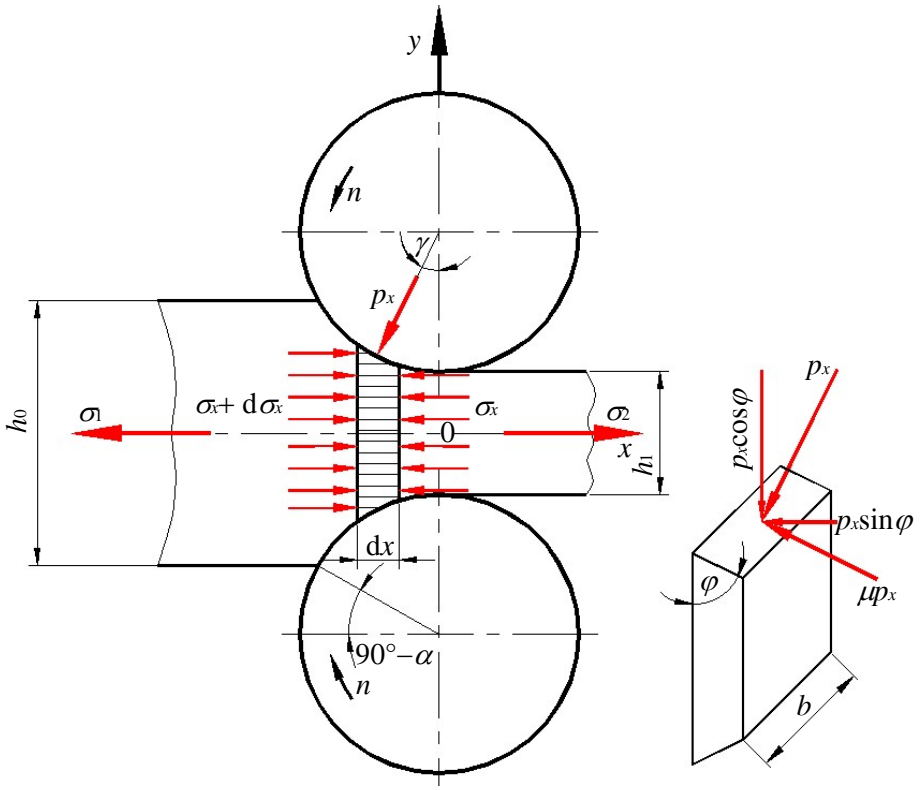


Figure 4. Dynamical model of rolling metal process and volume element [11].

Figure 4. illustrates the stresses acting on a vertical volume element inside the rolling gap. Employing the Coulomb friction model $\tau_x = \mu \cdot p_x$ and the yield criterion $\sigma_x = k - p_x$, and summing horizontal forces (x-axis), the Kármán's differential equation for pressure distribution in the rolle gap is obtained [5, 12]:

$$\frac{dp_x}{dx} - \frac{k}{y} \cdot \frac{dy}{dx} \pm \frac{\mu p_x}{y} = 0. \tag{5}$$

Celikov's solution Kármán's differential equation (5) is [13]:

$$p_x = \frac{2kh_n}{\Delta h(\delta - 1)}\left[\left(\frac{h_n}{h_1}\right)^{\delta} - 1\right]. \tag{6}$$

In equation (6) k is the yield stress of materials, δ is the non-dimensional coefficient:

$$\delta = \frac{2\mu L}{\Delta h}, \tag{7}$$

and h_n is the workpiece thickness at neutral point:

$$h_n = h_1\left[\frac{1 + \sqrt{1 + (\delta^2 - 1)\left(\frac{h_0}{h_1}\right)^{\delta}}}{\delta + 1}\right]^{\frac{1}{\delta}}. \tag{8}$$

There were several other solutions of the von Kármán's differential equation (5). Solutions were proposed and applied to particular rolling mills due to particular assumptions, such as Alexandra-Ford's formula for plate and hot mills, Sim's equation for hot mills, B&F solution for cold mills, Roberts' empirical solution for temper rolling, Stone's solution for ultrathin gage rolling, and Fleck and Johnson's theory for foil rolling. [14, 15] For vibration analysis, the most favorable is Celikov's solution (5).

The nonlinear rolling force F is the product of pressure (6) and projected contact area (3):

$$F = p_x \cdot A = b_{sr} \cdot L\frac{2kh_n}{\Delta h(\delta - 1)}\left[\left(\frac{h_n}{h_1}\right)^{\delta} - 1\right]. \tag{9}$$

Substituting the equations (7), (8), (2) and (1) $\rightarrow h_1 = h_0 - \Delta h$ (h_0= const.) into equation (9), it follows that the analytical nonlinear rolling force dependence on Δh is:

$$F = b_{sr}\sqrt{R\Delta h}\,\frac{2k}{\Delta h\left(\frac{2\mu\sqrt{R\Delta h}}{\Delta h}-1\right)}\left(h_0-\Delta h\right)\left[\frac{1+\sqrt{1+\left(\left(\frac{2\mu\sqrt{R\Delta h}}{\Delta h}\right)^2-1\right)\left(\frac{h_0}{h_0-\Delta h}\right)^{\frac{2\mu\sqrt{R\Delta h}}{\Delta h}}}}{\frac{2\mu\sqrt{R\Delta h}}{\Delta h}+1}\right]^{\frac{\Delta h}{2\mu\sqrt{R\Delta h}}}\cdot$$

$$\cdot\left[\frac{1+\sqrt{1+\left(\left(\frac{2\mu\sqrt{R\Delta h}}{\Delta h}\right)^2-1\right)\left(\frac{h_0}{h_0-\Delta h}\right)^{\frac{2\mu\sqrt{R\Delta h}}{\Delta h}}}}{\left(\frac{2\mu\sqrt{R\Delta h}}{\Delta h}+1\right)}-\left(h_0-\Delta h\right)^{\frac{2\mu\sqrt{R\Delta h}}{\Delta h}}\right]. \qquad (10)$$

In the equation (10) $b_{sr} \approx b$, k, R, μ, and h_0 have approximately constant values. The draft thickness Δh is a variable. The equation (10) is the basis for analysis the vibration in metal rolling process.

4. Single-DOF Model of Vibration in Metal Rolling Process

A single-degree-of-freedom (single-DOF) mechanical model of rolling process is presented in figure 5. The upper working roller and the lower working roller are constantly in contact with the workpiece material (sheet, strip). The assumption is that the loads and vibrations of the lower and upper roller are identical, so it is sufficient to analyze only one roller, in this case the lower one.

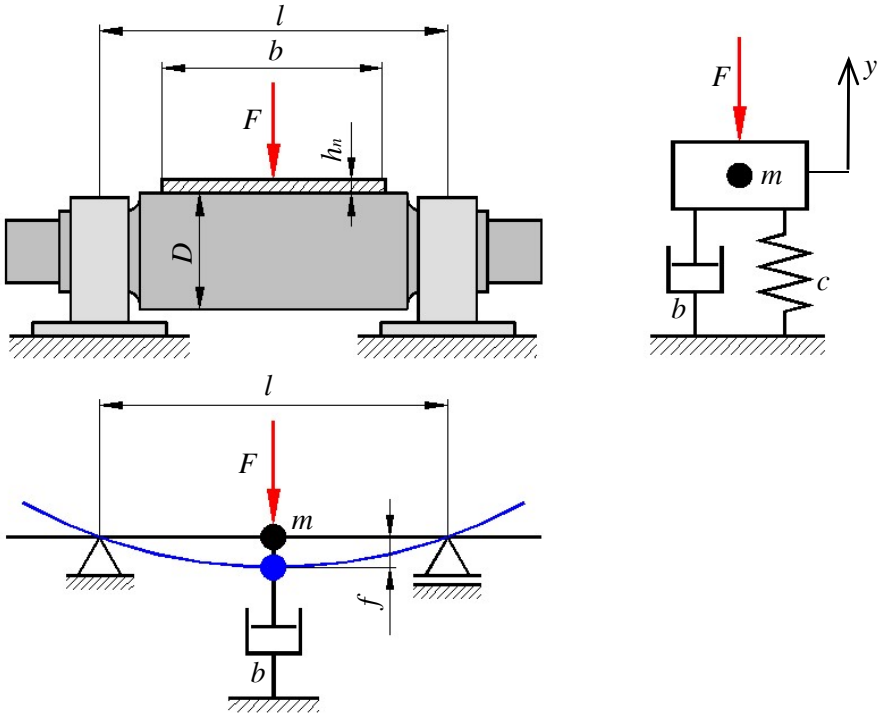


Figure 5. Single-DOF mechanical model of rolling process.

The elastic roller with the support assembly is approximated with a simply supported beam with a lumped (concentrated, discrete, rigid) mass *m* in the middle, figure 5. The elastic deflection of the beam caused by the non-linear rolling force *F* is [16]:

$$f = \frac{Fl^3}{48EI}, \tag{11}$$

where there are as follows:
F - rolling force acting on the center of the beam;
l - length of the beam between the supports;
E - modulus of elasticity;
I - area moment of inertia of cross section.

The beam could be simplified as a torsion spring of stiffness *c*:

$$c = \frac{F}{f} = \frac{F}{\frac{Fl^3}{48EI}} = \frac{48EI}{l^3}. \tag{12}$$

Therefore, the mechanical model of the single-DOF rolling process (elastic roller) could be approximated as a single-DOF (*y* coordinate) system with viscous damping *b* and a torsion spring of stiffness *c*, excited in forced vibration by force acting on lumped mass *m*.

In rolling mills, the sources of damping occur are: structural or hysteresis material damping, dry or solid friction Coulomb damping and viscous damping. The elastic roller is characterized by modal parameters like the angular natural frequency $\omega_n = \sqrt{c/m}$, the damping ratio $\zeta = b/(2m\omega_n)$ and the angular frequency $\omega_d = \sqrt{1-\zeta^2}$ of the damped free roll vibration. [7, 17]

A single-DOF model of rolling process includes the classical regenerative effect in the similar way as described for turning or milling. Hu first defined the regenerative effect in rolling process in analogy to effect in metal cutting process [18].

The physical basis of this phenomenon is well known in the literature. Because of some external perturbations, the rolls start a damped vibrations relative to the workpiece, and the surface of the workpiece becomes wavy, figure 6. After the one revolution of the rolls, the workpiece thickness will vary because of this wavy surface. As a consequence, the rolling force depends on the actual and delayed values of the relative displacement of the rolls and the workpiece, where the length of the delay is equal to the time-period τ of the revolution of the rolls. More simply, the present deformation and the one made one revolution earlier might overlap, causing metal thickness and rolling force variations. The associated time delay is the time-period τ of one revolution of the rolls. [6, 7, 10, 18, 19]

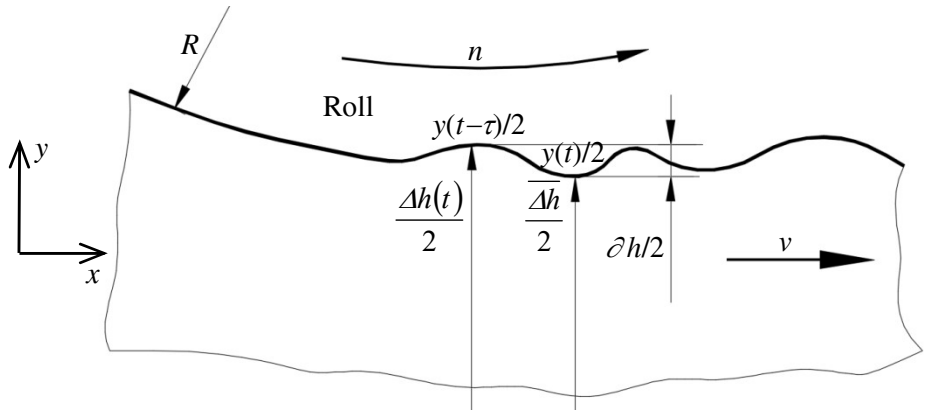


Figure 6. Regenerative effect in rolling process.

The theoretical draft thickness is $\overline{\Delta h}$, the constant workpiece width is *b*. The actual draft thickness is:

$$\Delta h(t) = \overline{\Delta h} + y(t-\tau) - y(t), \tag{13}$$

where is τ the time-period of one revolution of the rolls:

$$\tau = \frac{2\pi}{\Omega} = \frac{2\pi}{\frac{n\pi}{30}} = \frac{60}{n} \text{ [s]}, \tag{14}$$

where is:
- Ω [rad/s] the angular velocity of the roller,
- *n* [rpm] the number of full roller rotations.

The analytical nonlinear rolling force *F* (10) can be approximated with a polynomial of degree *n* (figure 7.):

$$F = \sum_{i=0}^{n} a_i (\Delta h)^i \ . \tag{15}$$

The value of *n* depends on how well a polynomial (15) fitted to the analytical force (10). For a goodness of fit test, the coefficient of determination R^2 between analytical and approximated function be used.

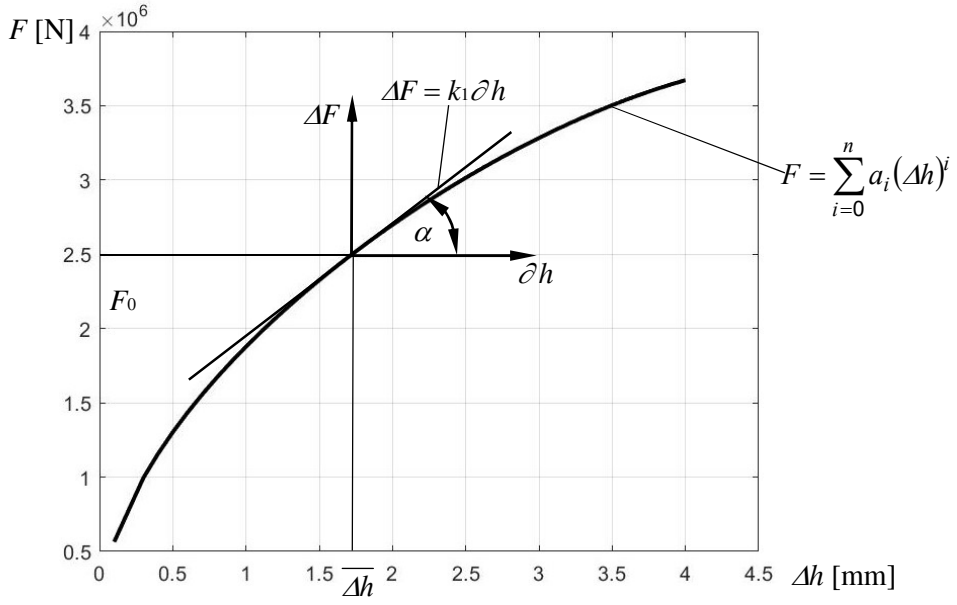


Figure 7. Rolling force characteristic.

The first-degree Taylor series approximation of the rolling force variation [7]:

$$\Delta F = F - F_0\,, \tag{16}$$

with respect to the draft Δh variation:

$$\partial h = \Delta h(t) - \overline{\Delta h} = y(t-\tau) - y(t), \tag{17}$$

assumes the form:

$$\Delta F \approx k_1(\partial h) = k_1\big(y(t-\tau) - y(t)\big). \tag{18}$$

The rolling coefficient k_1 assume the form, figure 6.:

$$k_1 = \left.\frac{dF}{d(\partial h)}\right|_{\overline{\Delta h}}. \tag{19}$$

The differential equation of vibration has the form [18]:

$$\ddot{y}(t) + 2\zeta\omega_n\dot{y}(t) + \omega_n^2 y(t) = \frac{1}{m}\Delta F\,. \tag{20}$$

When the rolling force variation (18) substituted in the equation (20), the following equation is obtained:

$$\ddot{y}(t) + 2\zeta\omega_n\dot{y}(t) + \omega_n^2 y(t) = \frac{1}{m}k_1\big(y(t-\tau) - y(t)\big). \tag{21}$$

Finally, the delay-differential equation (DDE) of vibration takes the form:

$$\ddot{y}(t)+2\zeta\omega_n\dot{y}(t)+\left(\omega_n^2+\frac{k_1}{m}\right)y(t)-\frac{k_1}{m}y(t-\tau)=0\,. \tag{22}$$

In the delay-differential equations (21) and (22) $y(t-\tau)$ denotes delayed value of $y(t)$.

5. Numerical Analysis

Delay-differential equation (22) has been solved numerically for the realistic rolling process parameters, which shown in table 1.

Table 1. Realistic rolling process parameters.

Parametar	Symbol	Value	Unit
Roll diameter	D	100	mm
Contact width	b	500	mm
Thickness at entry	h_0	6	mm
Friction coefficient	μ	0,1	-
Area moment of inertia	I	4908738,521	mm^4
Modulus of elasticity	E	210	kN/mm^2
Material density	ρ	$785\cdot10^{-8}$	kg/mm^3
Rolling coefficient	k_1	1815,5	kN/mm
Yield stress of materials	k	0,316	kN/mm^2
Length of the beam	l	1000	mm
Mass of roll	m	61,65	kg
Contact stiffness	c	49,5	kN/mm
Angular natural frequency	$\omega_n=\sqrt{c/m}$	0,896	rad/s
Initial condition	y_0	0,1	mm
Damping ratio	ζ	0,01	-

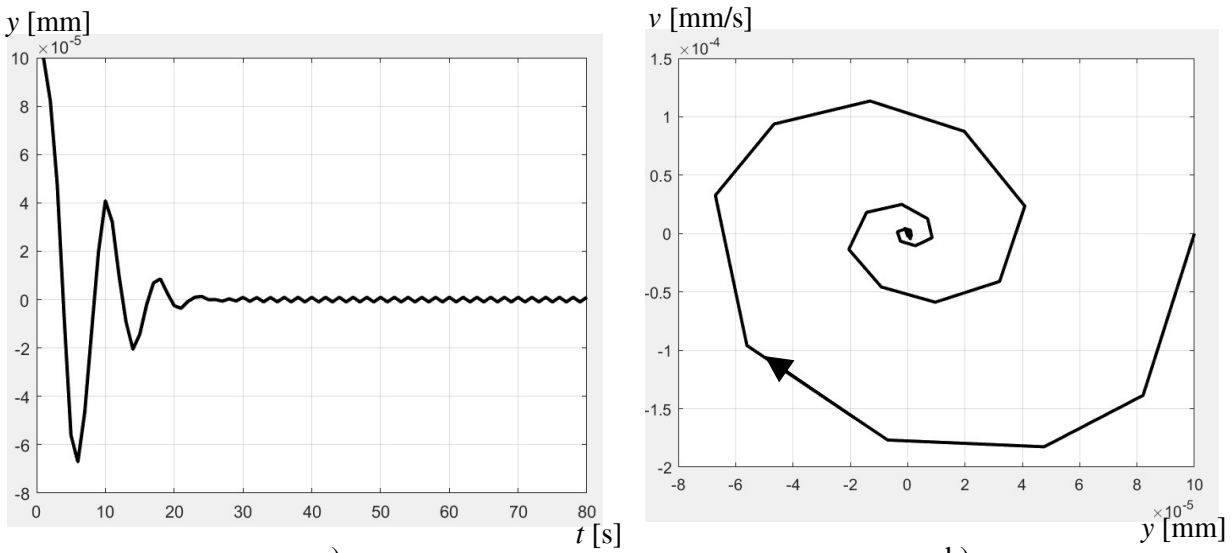
Inserting the values from table 1. into equation (10) obtained the numerical values of the rolling force depending on Δh, which are approximated by a polynomial of degree 4:

$$F(\Delta h)=-18{,}87(\Delta h)^4+189(\Delta h)^3-770{,}7(\Delta h)^2+2078(\Delta h)+411{,}1\,. \tag{23}$$

The coefficient of determination R^2 between the realistic analytical and approximated function (23) is $R^2 = 0{,}9997$. The obtained value of R^2 confirmed that, for the realistic parameters, the approximated function fitted very well to the analytical function.

According to equation (19), for the theoretical draft thickness is $\overline{\Delta h}=0{,}18$, the rolling coefficient $k_1 = 1815{,}5$ [kN/mm^2] is obtained.

The numerical solution DDE (22) for the realistic parameters of the rolling process, for various values of the delay time τ, is shown below.



a) b)

Figure 8. Numerical solution, time history and phase portrait for $\tau = 0{,}1$ [s].

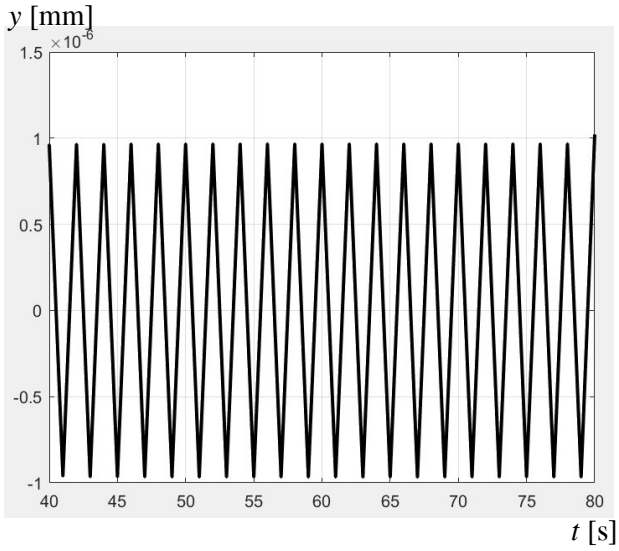


Figure 9. Stable numerical solution for $\tau = 0{,}1$ [s].

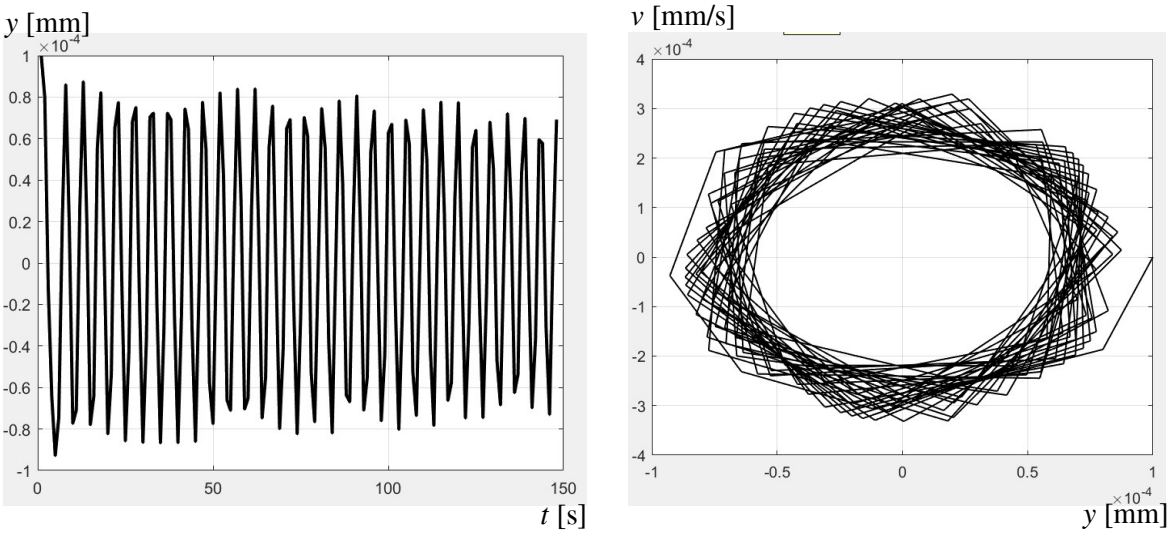


Figure 10. Numerical solution, time history and phase portrait for $\tau = 0{,}8425$ [s].

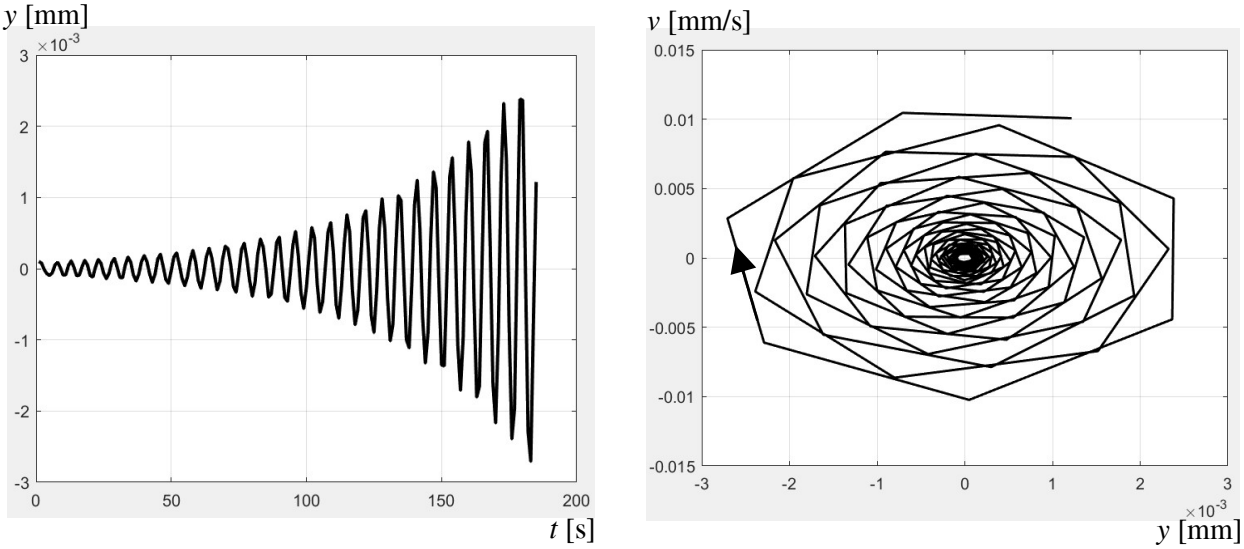


Figure 11. Numerical solution, time history and phase portrait for $\tau = 0{,}88$ [s].

The numerical solution DDE (22) have three possible solution scenarios. The first solution is stable vibration, for $\tau < 0{,}8425$, figures 8. After the initial transient large amplitudes, for a longer period of time the vibrations stabilize, where the amplitudes have small values, figure 9. The second solution scenario is periodic movement with relatively large amplitudes, for $\tau \approx 0{,}8425$, figure 10. This solution is at the bifurcation zone, where a small change in the parameter τ causes a different behavior of the system. Finally, the third solution scenario is unstable vibrations with increase the amplitude for a longer period of time, for $\tau > 0{,}8425$, figure 11.

In addition to numerical solutions in the time domain (figures 8, 10. and 11.) phase portraits are shown, with phase coordinates, displacement y and speed v, which are important for determining the stability of the rolling process.

6. Stability Analysis of Vibration in Metal Rolling Process

The stability of DDE is well studied in the literature, for example [10, 20, 21]. The stationary rolling is described by the constant draft thickness $\overline{\Delta h}$, i.e. by the trivial solution y(t) = 0 in the delay-differential equation of vibration (21). Its asymptotic stability in the Lyapunov sense is determined by the characteristic function D. This comes either by the application of the Laplace transformation in (22) or simply by the substitution of the trivial solution $y(t) = Ae^{\lambda t}$ ($A,\lambda \in \mathbf{C}$):

$$\lambda^2 + 2\zeta\omega_n\lambda + \omega_n^2 + \frac{k_1}{m} - \frac{k_1}{m}e^{-\lambda\tau} = 0\,. \tag{24}$$

The borders of the stability domains in the stability chart can be constructed by substituting pure imaginary characteristic roots $\lambda = i\omega$ into the characteristic equation (24), which has infinitely many solutions in the complex domain. In this paper the stability was analyzed by numerical solutions DDE (figures 8-11), which is much simpler than analysis by the characteristic equation (24).

Numerical solutions of DDE and phase portraits show that two phenomena characteristic of two-dimensional dynamic systems occur in rolling processes: limit circle and Hopf bifurcation. A limit cycle is an isolated closed trajectory. Isolated means that neighboring trajectories are not closed, they spiral either toward or away from the limit cycle, figure 12. [22, 23, 24]

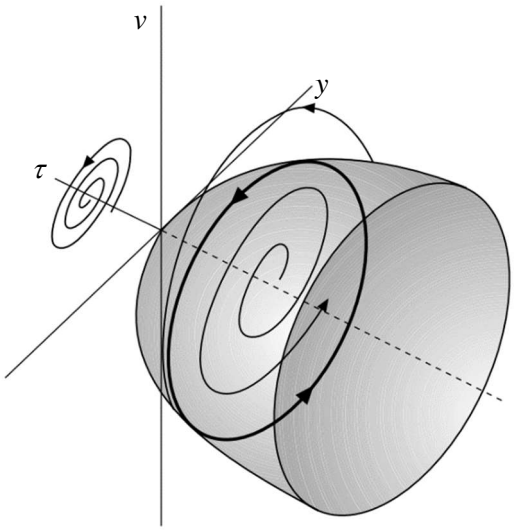


Figure 12. Limit circle [24].

If all neighboring trajectories approach the limit cycle, then the limit cycle is stable or attracting. Otherwise, the limit cycle is unstable, or in exceptional cases, half -stable. Stable limit cycles are very important scientifically - they model systems that exhibit self-excited vibrations [23].

A bifurcation is qualitative changes of dynamical system, it provides models of transition and instabilities as control parameter is varied. A bifurcation occurs when a small smooth change made to the bifurcation parameter of a system causes a sudden change in its behavior.

Suppose a two-dimensional system has a stable fixed point, figure 8. What are all the possible ways it could lose stability as a bifurcation parameter varies? The eigenvalues of the characteristic equation (23) are the key. If the fixed point is stable, the eigenvalues must lie in the left half-plane Re $\lambda < 0$. To destabilize the fixed point, it needs one or more of the eigenvalues to cross into the right half-plane as the bifurcation parameter varies, figure 13. [22, 23]

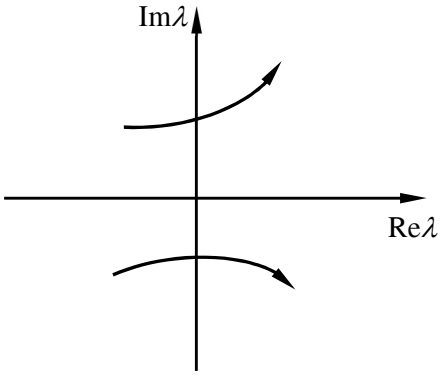


Figure 13. Hopf bifurcation [22].

The rolling process settles down to equilibrium through exponentially damped vibrations for $\tau <$ 0,8425, figure 8. and 9. The decay rate depends on a bifurcation parameter τ. If the decay becomes slower and slower and finally changes to growth at a critical value $\tau \approx 0{,}8425$, the equilibrium state will lose stability. In many cases the resulting motion is a small-amplitude, sinusoidal, limit cycle oscillation about the former steady state, figure 10. The system has undergone a supercritical Hopf bifurcation. A subcritical Hopf bifurcation occurs for $\tau > 0{,}8425$, where the large- amplitude limit cycle is the only attractor. Solutions are forced to grow into large-amplitude oscillations, figure 11.

Therefore, in the rolling the Hopf bifurcation occur. The bifurcation parameter is the time delay, from whose value the system vibrates stably or unstable. The critical value of the bifurcation parameter is $\tau \approx 0{,}8425$ for selected realistic parameters, table 1.

The Hopf bifurcation and limit cycle can be the cause of chaotic vibrations, according to the so-called the quasi-periodic scenario the route to chaos. In this scenario, the system begins with a limit cycle trajectory. As a control parameter is changed, a second periodicity appears in the behaviour of the process. This bifurcation event is a generalization of the Hopf bifurcation. This route is sometimes called the Ruelle - Takens scenario after D. Ruelle and F. Takens, who first suggested the theoretical possibility of this route. The main point here is it that to expects a long sequence of different frequencies come in as the control parameter is changed. However, at least in some cases, the vibrations become chaotic instead of introducing a third distinct frequency for its motion. [25]

7. Conclusion

Rolling is metal forming process with complex geometry and dynamics. Celikov's solution Kármán's differential equation for pressure distribution in the rolle gap results in the equation for the analytical nonlinear rolling force dependence on the draft thickness. The mechanical model of the single-DOF rolling process was approximated as a single-DOF system with viscous damping and a torsion spring, excited in forced vibration by the rolling force acting on lumped mass. The forcing function is a function of the displacement of the system mass so that self-excited vibrations occur. The analytical nonlinear rolling force is more than complex, so it is approximated with a polynomial of degree 4 in the numerical solution. A single-DOF model of rolling process includes the classical regenerative effect where the associated time delay is the time-period of one revolution of the rolls.

The resulting mathematical model vibration in metal rolling process is a simple-second-order DDE. DDE cannot be solved analytically, so that it has been solved numerically for the realistic rolling process parameters. The numerical solutions were displayed graphically as time history and phase portrait.

The numerical solution DDE have three possible scenarios for vibration in rolling process, depending on the value of the time delay: stable vibration, periodic movement with relatively large amplitudes and

unstable vibrations with increase the amplitude for a longer period of time. This means that for a certain value of the delay time, a supercritical or subcritical Hopf bifurcation has occurred.

As the delay time increases so does the vibration instability and vice versa. That is, by increasing the number of revolutions of the roller, stabilization of vibrations occurs, which is analogous to the Laval effect.

Therefore, in the rolling process, one should strive for a higher actual number of revolutions of the rollers, in order to reduce the vibration amplitudes and obtain a high-quality workpiece.

In this paper a vibration model for rolling process is analyzed in analogy to analysis in metal cutting process, according to research by Stépán, Moon, Insperger, Kalmár-Nagy and Hu. This was possible because the classical regenerative effect for rolling process is similar as for turning or milling. The results of numerical simulations are also similar, which further confirms this method of analysis. This analogy does not apply to other forming processes, primarily due to the absence of a regenerative effect. Therefore, it is necessary to develop other vibration analysis approaches.

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Additive manufacturing technologies as mechanisms for implementing the paradigm of personalized production

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Abstract. The manufacturing industry has witnessed a series of transformative shifts in production paradigms over the years, driven by changes in market dynamics and social demands. This article explores the evolution of production systems from craft production to personalized production, highlighting the major paradigms that have shaped industrial manufacturing. The six identified paradigms include craft production, mass production, mass customization, ubiquitous manufacturing, and personalized production. Each paradigm is characterized by distinct features and drivers that have influenced the way products are designed, manufactured, and consumed. The emergence of personalized production, fuelled by advancements in additive manufacturing technologies, has challenged traditional mass production models and opened up new opportunities for customization and consumer empowerment. This article also provides an overview of additive manufacturing technologies, particularly focusing on fused deposition modelling (FDM), and the materials commonly used in FDM processes. The potential of personalized production and the role of additive technologies in achieving customized, functional, and versatile manufacturing are discussed. The experimental section of the paper demonstrates the practical application of these technologies in creating personalized products, emphasizing the importance of material selection and its impact on print quality and cost.

1. Introduction

Industrial production has undergone significant transformations in response to market and societal changes, leading to the identification of various manufacturing paradigms. Based on a literature review [1-9], six major manufacturing paradigms have been identified that have profoundly influenced industrial manufacturing over the past two centuries: craft production, mass production, mass customization, ubiquitous manufacturing, regionalized production, and personalized production.

In the 21st century, industrial production is undergoing profound changes due to the influence of globalization. This shift is characterized by regionalization, a widespread presence, and an increasing demand for personalized products. Customers now seek products that align with their unique preferences, resulting in a significant rise in product variations and the diversity of required production volumes.

To meet these evolving customer demands, companies in the realm of modern product development are leveraging advanced technologies such as computer-aided design (CAD), simulations, 3D printing, and digital modelling. These technologies play a crucial role in enabling personalized production, allowing customers to actively participate in the design and customization of products based on their specific needs. This level of customization can involve selecting different features, designs, colours, materials, or even resizing options.

By harnessing these advanced technologies, companies can provide customers with a tailored and individualized product experience. This approach not only caters to the unique preferences of customers but also empowers them to have greater control over the products they purchase. The integration of CAD, simulations, 3D printing, and digital modelling into the personalized production process represents a paradigm shift in the way products are designed, manufactured, and consumed. It opens up new possibilities for innovation, creativity, and customer satisfaction in the industrial production landscape.

The article provides an overview of manufacturing paradigms, with a specific focus on the implementation of the personalized production paradigm. It highlights additive technologies as a critical mechanism for realizing personalized production. The experimental section of the article showcases the application of state-of-the-art 3D technologies and additive manufacturing processes in the creation of a customized product.

The article is divided into two sections. The first section provides an overview of the historical development of manufacturing paradigms and highlights additive manufacturing technologies as crucial mechanisms for implementing the personalized production paradigm. In the second section, the article delves into the experimental aspect, offering a detailed description of the process involved in creating a personalized product using additive manufacturing technology.

2. Materials and methods

2.1. Evolution of manufacturing paradigms: from Craft production to Personalised production

The manufacturing paradigm represents a revolutionary, novel, and integrated manufacturing model that emerges as a response to changes in the market and social environment. It is achieved through the creation of a new type of manufacturing system [4]. The evolution of manufacturing systems through manufacturing paradigms is described in works [5-7].

Today, we can identify six major manufacturing paradigms that have shaped the manufacturing of industrial products in the last two centuries: 1) craft production, 2) mass production, 3) mass customization, 4) ubiquitous manufacturing (globalization), and 5) personalized production, as shown in Figure 1.

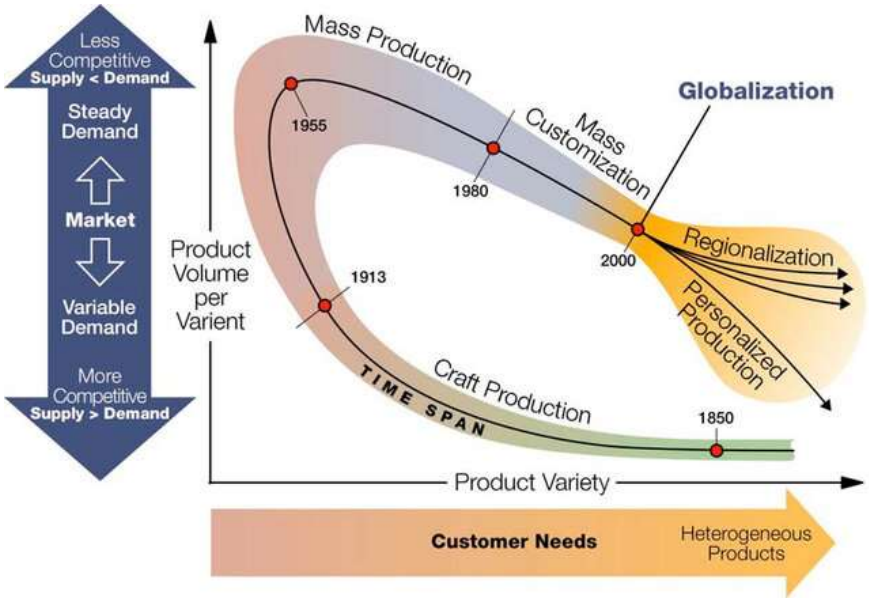


Figure 1. Manufacturing paradigm shifts and the drivers [1].

In craft production, products were made in small quantities, manually, and based on specific orders for individual customers. In this type of production, human craftsmanship played a key role in both the

design of the product and its manufacturing process. The quality and other characteristics of each product were determined by the specific requirements of each customer.

In [1], the author describes the characteristics of craft production as follows: 1) high product variety: craft production is known for its wide range of products, each crafted with unique details and features; 2) extremely small batch sizes: craft production involves producing very limited quantities of identical products, often tailored to meet specific customer demands; 3) pull business model: the business model employed in craft production follows a "*pull*" approach, where production is initiated based on customer orders. This contrasts with a "*push*" model, where products are manufactured in anticipation of demand; 4) universal machines: craft production utilizes versatile machines capable of performing various manufacturing operations, allowing for flexibility and adaptation to different product requirements; 5) human factor: craft production places significant emphasis on the human element, requiring highly skilled and trained craftsmen to achieve the desired quality and craftsmanship in the products.

In the early 20th century, a significant development in the market occurred, opening up opportunities for the production of larger quantities of products for mass consumption through mass or serial production methods. Mass production brought several advantages over craft production, primarily due to a radical increase in productivity and a reduction in unit costs. The large volume of produced goods covered the expenses invested in equipment, machine labour, engineering, and education [5].

Mass production is based on the push business model (develop, manufacture, assemble, sell). The key production technology of mass production is Ford's moving assembly line. Dedicated Manufacturing Lines (DML), where machines replaced human labour, were developed specifically for this type of production [6]. This paradigm is rooted in the principles of scientific management outlined in [10].

Between 1970 and 2000, manufacturing became more flexible, enabling mass customization to cater to the specific needs of individual customer groups. Mass customization is a paradigm that arises from changing social demands. It can be defined as [7]: "*...the production of products and services that meet individual customer needs with efficiency close to mass production*."

The aim was to produce personalized products with efficiency similar to mass production. The production of a wide variety of products is an imperative within this paradigm. Flexible Manufacturing Systems (FMS) and Computer Integrated Manufacturing (CIM) play a crucial role in achieving such outcomes.

In this context, the business model follows a pull approach, where the customer places an order and makes payment before the product enters production, as depicted in Figure 1.

The industrial manufacturing of the 21st century, under constant pressure from globalization, is characterized by regionalization, ubiquitous presence, and increasing product personalization. Every customer seeks products tailored to their own preferences, significantly increasing the number of product variations and the diversity in required production quantities.

The separation of business processes beyond the existing business system, production in different locations, diverse types of global economic organizations, new forms of product life cycles, systems, and factories, the rise of diverse product models and the number of their variations, has paved the way for regionalized (ubiquitous) production.

Regionalized production [8] is an extension of variant production, emphasizing variations adapted to the specific characteristics (cultural, legal, environmental, etc.) of a particular region. In personalized production [9], customers are involved in the design of the products they purchase. It is precisely this co-creation that drives the creation of new value [11].

In recent years, the concept of personalized production has emerged as a game-changer in the field of manufacturing. This innovative approach challenges the traditional notion of mass production by emphasizing customization, individualization, and consumer empowerment. Personalized production represents a profound shift in how goods are designed, produced, and consumed, with the potential to revolutionize entire industries.

The benefits of personalized production extend beyond mere customization. By involving consumers in the design process, manufacturers gain invaluable insights into their preferences and can tailor their

offerings accordingly. This collaboration between producers and consumers fosters a sense of co-creation, empowering individuals to actively participate in shaping the products they use.

One of the key drivers behind the rise of personalized production is advancements in additive technologies, particularly additive manufacturing. Additive technologies enable the creation of highly complex and intricate designs, allowing for a level of customization that was previously unimaginable. Through these technologies, manufacturers can build products layer by layer, resulting in endless possibilities for customization.

2.2. Additive manufacturing technologies

Additive manufacturing, also referred to as 3D printing, has emerged as a ground breaking technology that enables the fabrication of tangible objects based on a 3D digital model [12-14]. This innovative process involves the sequential deposition or solidification of materials, layer by layer, to construct the final product. The utilization of 3D printing offers a multitude of benefits compared to conventional manufacturing methods, including the capacity to generate intricate geometries, customization options, accelerated prototyping, and the ability to cater to on-demand production requirements.

Modern additive manufacturing processes have undergone several phases in terms of their applications, leading to the evolution of associated terminology. Initially, these processes were primarily used for rapid prototyping (RP). However, the term "*rapid*" should be understood conditionally, as the production time for prototypes depends on the size of the product and the layer thickness used in its construction. Typically, production can take anywhere from a few minutes to several days. While this may not be considered fast in absolute terms, it does offer a significant time advantage when compared to traditional prototyping and manufacturing methods. Products created using these processes at the end of the previous century were primarily used to enhance the product development process [15].

The next step in the application of modern additive manufacturing is rapid tooling (RT), which involves using additive processes to produce polymer, ceramic, or metal tools and molds, as well as their key components. By leveraging the principle of layered construction, additive manufacturing enables significant reduction in the production time of the most complex geometrical parts of tools and molds [15].

The development of materials used in modern additive layer manufacturing processes has led to the emergence of rapid manufacturing (RM) and direct digital manufacturing (DDM), enabling the production of small series and individual final products without the need for additional tooling [15].

After years of significant advancements and widespread use of RP/RT/RM processes, the International Committee F42 for additive manufacturing processes was established in 2009 by ASTM International. One of its primary tasks was to provide standardized terminology for these processes.

The International Committee F42 of ASTM International defines additive manufacturing as the process of joining materials to create objects directly from 3D computer models, typically layer by layer, which is in stark contrast to subtractive manufacturing methods [15,16].

Additive manufacturing processes can also be a solution to current trends of mass personalization to meet customer demands in the market. Additive manufacturing processes enable a cost-effective approach in cases where products need to be tailored to individual customers. On the other hand, when utilizing additive manufacturing processes for direct manufacturing, it is crucial to meet production requirements such as quality control, traceability, and quality repeatability, which are receiving increasing attention due to the convergence of quality standards between additive manufacturing-produced products and those made through conventional manufacturing processes [17].

The additive manufacturing process begins by creating a virtual CAD model of the product. This model is then sliced into 2D cross-sections using specialized "*slicer*" software. The resulting 2D data is then translated to the 3D printer, which uses this information to manufacture the physical product layer by layer [18-21].

The mechanisms for implementing additive manufacturing processes are referred to as additive technologies.

One of the key advantages of additive technologies is their ability to create complex geometric shapes that are challenging to achieve with traditional manufacturing processes. Through 3D printing, objects with internal cavities, intricate structures, and unconventional forms can be fabricated. This opens up innovative approaches to product design, removing the constraints imposed by conventional material processing methods.

Additive technologies enable personalized production. Each item can be tailored to individual needs and customer requirements. For instance, in the field of medicine, prosthetic parts such as prostheses and dental restorations can be produced that are perfectly customized to individuals. This not only enhances the comfort and functionality of the products but also contributes to a better quality of life for the users.

Additive technologies can be systematically categorized based on the manufacturing process, the source of energy used, and the size of the produced object, the layering method employed, the type of output material, and other factors.

The most important manufacturing processes [22] include: 1) stereolithography (SLA), 2) selective laser sintering (SLS), 3) selective laser melting (SLM), 4) fused deposition modelling (FDM), laminated object manufacturing (LOM), etc.

FDM, also known as fused filament fabrication (FFF) [23-25] is a prominent additive manufacturing technology that has gained significant traction in various engineering applications. It is widely utilized in the production of personalized products, as well as in industries such as automotive, aerospace, and medical engineering, among others.

In the FDM process, a filament of thermoplastic material, typically in the form of a spool, is fed into a heated nozzle. The nozzle melts the filament, and the molten material is extruded onto a build platform in a precise pattern determined by a computer-controlled mechanism. The material quickly solidifies upon deposition, bonding with the previously laid layers. This process is repeated layer by layer until the desired object is fully constructed. Figure 2 shows a simplified scheme of an FDM process and product manufacturing process itself with this technology.

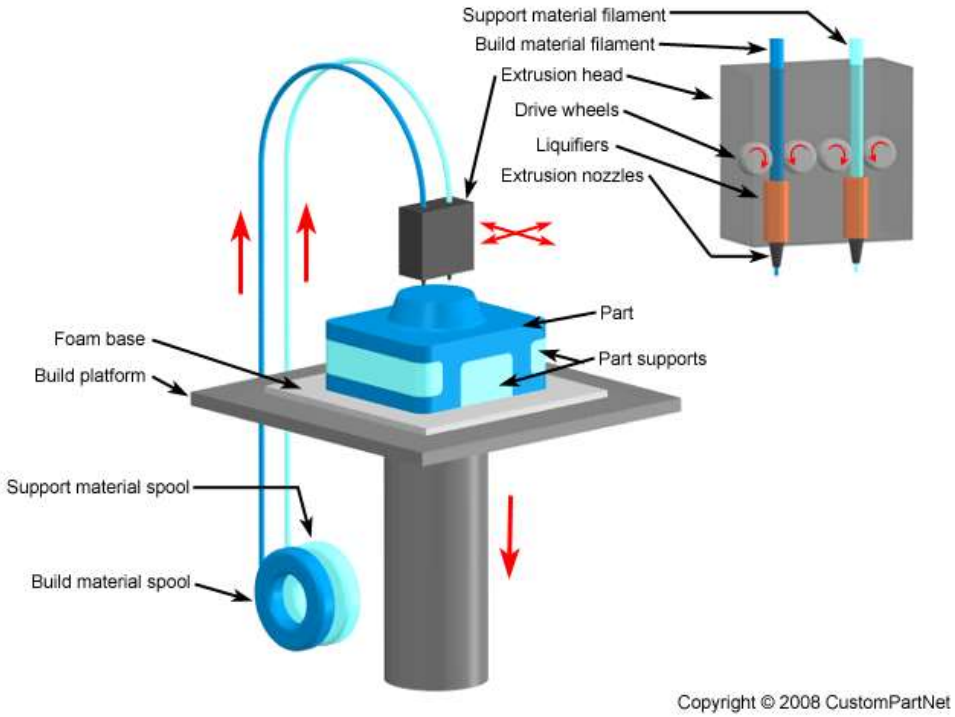


Figure 2. FDM printing process [26].

The choice of materials plays a crucial role in the FDM process, as it directly impacts the final properties and performance of the printed parts. The various materials commonly used in FDM technology are polyamide (PA), polylactic acid (PLA), polycarbonate (PC), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PETG), etc.

Among the various materials used in FDM 3D printing, PLA and PETG have gained significant popularity due to their favourable mechanical properties and the ease of use. To further enhance their performance, reinforcing additives such as carbon fibers (CF) have been incorporated into these materials, resulting in composites with superior mechanical strength and stiffness.

The materials used in FDM technology have a significant impact on the quality, functionality, and performance of the printed objects. With a wide range of thermoplastics and specialty filaments available, FDM offers versatility and the ability to cater to diverse application needs. As the field of additive manufacturing continues to advance, we can expect further developments and innovations in materials for FDM, expanding the possibilities for creating functional and customized products.

3. Experimental Procedures

The following paper presents the development and production of a phone holder based on the principles of the personalized production paradigm and additive manufacturing technology. Additive manufacturing technologies and advanced materials enable the production of conceptual and functional prototypes of phone holder in a relatively short time frame, from the creation of a 3D model to obtaining the final printed product. The process of creating and production a model of a phone holder is illustrated in the IDEF diagram at the Figure 3.

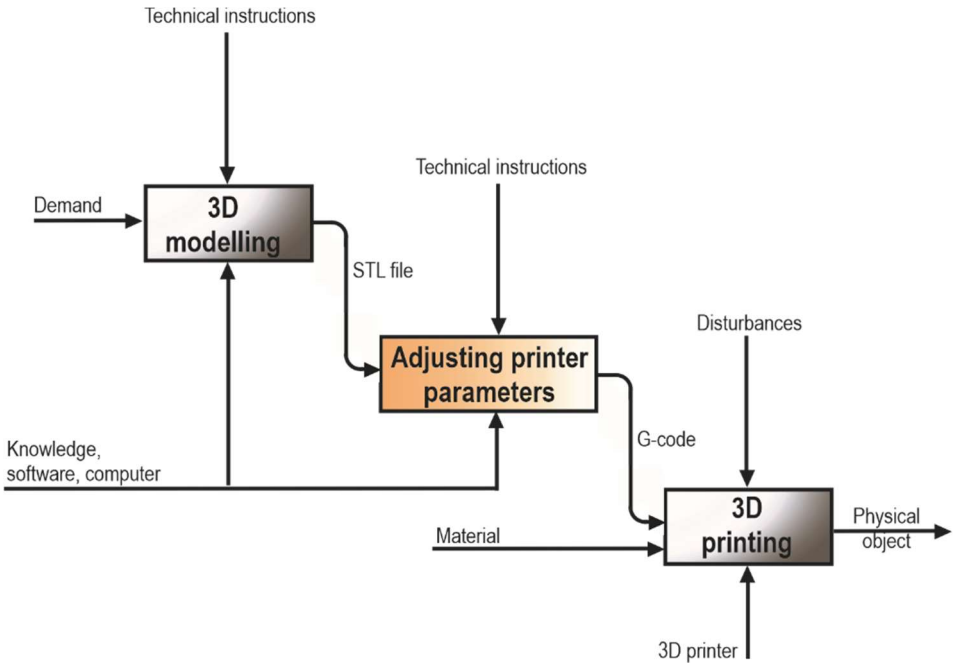
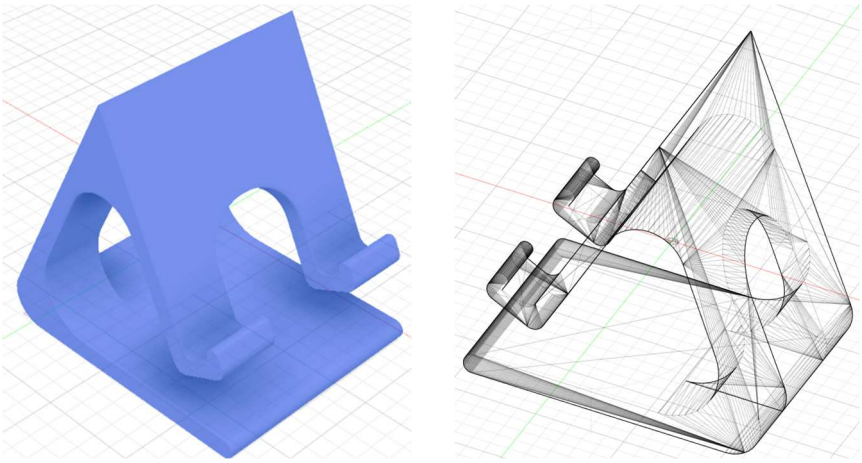


Figure 3. IDEF diagram of the phone holder physical model production.

The process diagram consists of a creation of a model of the phone holder, generation of G-code, and production of a physical model using FDM 3D printing technology.

In a modelling environment (3D CAD SolidWorks 2019), we created a 3D model of the phone holder according to personal requirements, see Figure 4.

After developing the 3D model of the phone holder, the SolidWorks file was converted into STL format. Then, the STL file was transferred to FlashPrint5 – 3D printing software. FlashPrint5 – 3D printing software was used to adjusting printer parameters for 3D printing, see Figure 5.



a) b)

Figure 4. 3D model of the phone holder: a) solid, b) mesh.

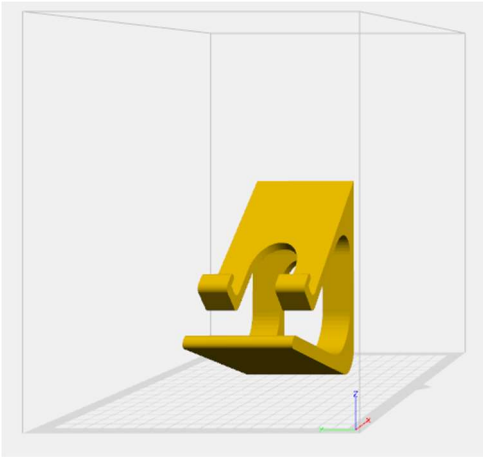


Figure 5. 3D model of the phone holder in FlashPrint5 – 3D printing software.

For this study, three 3D printing material types, ABS, PLA-CF, and PETG-CF, have been used.

ABS is a durable and impact-resistant thermoplastic known for its strength, toughness, and ability to withstand higher temperatures. It is commonly used in applications that require robust and functional parts, such as automotive components, consumer goods, and electronics.

Another commonly used material is PLA-CF. It is a composite material formed by blending polylactic acid (PLA) with carbon fibers. PLA is a biodegradable and renewable thermoplastic derived from plant-based sources, such as corn or sugarcane. By incorporating carbon fibers, the resulting PLA-CF material exhibits enhanced mechanical properties, including increased stiffness, strength, and resistance to deformation. The carbon fibers, known for their tensile strength and low weight, reinforce the PLA matrix, making it suitable for applications requiring lightweight but durable components.

PETG-CF is another popular choice for FDM. PETG-CF is a composite material composed of polyethylene terephthalate glycol (PETG) and carbon fibers. PETG is a thermoplastic polymer known for its excellent transparency, chemical resistance, and impact strength. By incorporating carbon fibers into PETG, the resulting PETG-CF material exhibits improved mechanical properties, including increased tensile strength, stiffness, and heat resistance. PETG-CF demonstrates good printability, making it a popular choice for 3D printing applications.

Material specifications of ABS, PLA-CF, and PETG-CF materials defined by Flashforge manufacturer are presented in Table 1.

Table 1. Material specifications of ABS, PLA-CF, and PETG-CF material defined by Flashforge manufacturer.

Material properties	ABS	PLA-CF	PETG-CF
Colour	Blue	Black	Bleck
Diameter [mm]	1.75	1.75	1.75
Nozzle temperature [°C]	230-250	200-230	230-250
Bed temperature [°C]	100-110	40-50	60-80
Water absorption (equilibrium in water, 23□)	1	0.5	0.8
Tensile Strength [MPa]	35-40	40-45	40-43
Flexural Strength [MPa]	65-70	85-95	75-85
Cost [euro/kg]	23.90	49.00	31.90

FlashPrint5 – 3D printing software enables adjusting printer parameters and manage and monitor the print progress. Main printing parameters for all materials are presented in Table 2.

Table 2. Main 3D printing parameters for ABS, PLA-CF, and PETG-CF materials.

3D printing parameter	ABS	PLA-CF	PETG-CF
Nozzle size	0.4	0.4	0.4
Nozzle (extruder) temperature [°C]	240	230	230
Bed (platform) temperature [°C]	100	45	80
Layer height [mm]	0.30	0.30	0.30
First layer height [mm]	0.40	0.40	0.40
Base print speed [mm/s]	50	80	60
Travel speed [mm/s]	100	100	100
Fill density [%]	15	15	15
Fill pattern	triangle	triangle	triangle
Fill angle [°]	45	45	45
Enable raft	+	-	-

In the slicer FlashPrint5 – 3D printing software user has the option to select one of the 4 different fill patterns. For this paper, on all phone holder models, "*Triangle*" pattern with 45° fill angle was used with 15% fill densities, see Figure 6.

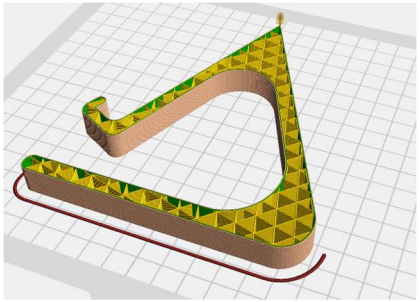


Figure 6. The phone holder with "*Triangle*" infill pattern.

The phone holders were manufactured on the Adventurer 4 FDM 3D printer (Figure 7). The technical specifications of the Adventurer 4 FDM 3D printer are presented in Table 3.

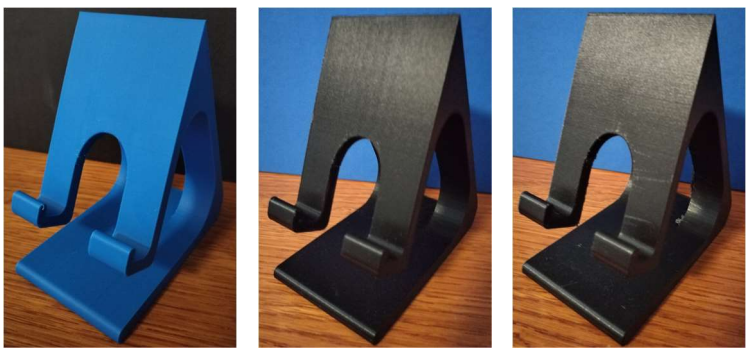
Figure 7. Adventurer 4 FDM 3D printer.

Table 3. The technical specifications of the Adventurer 4 FDM 3D printer

3D printing specifications	
Extruder Quantity	1
Printing Precision	±0.1 mm
Build Volume	220x200x250 mm
Nozzle Diameter	0.4 mm (default); 0.6/0.3 mm (optional)
Printing Speed	10-150 mm/s
Maximum Extruder Temperature	240□/265□
Supported Filament	ABS/PLA/PC/PETG/PLA-CF/PETG-CF
Platform Heating Temperature	110□
Connectivity	USB/WIFI/Ethernet
Leveling	Nine Point Auto Calibration
Touch Screen	4.3-inch
Resume Printing after Power Failure	+
Remote Video Monitoring	+

4. Results

The printed 3D models of the phone holder are presented in Figure 8.



a) b) c)

Figure 8. The printed 3D models of the phone holders: a) ABS, b) PLA-CF, c) PETG-CF.

After 3D printing all three phone holder models, the experimental data (print time, mass, material use) were collected (Table 4) and analysed. A visual inspection of the produced models was also conducted regarding deviations from defined dimensions and surface quality.

Table 4. Experimental data for ABS, PLA-CF, and PETG-CF models.

Experimental data	ABS	PLA-CF	PETG-CF
Print time [min]	423	307	342
Mass [g]	68	81	87
Material use [m]	31.46	29.99	31.17
Cost of the material [euro/part]	1.62	3.97	2.77

Analysing print time, it can be obtained that the phone holder model 3D printed from ABS material demonstrated the highest (423min) and the phone holder model from PLA-CF material the lowest (307min) value, see Figure 9.

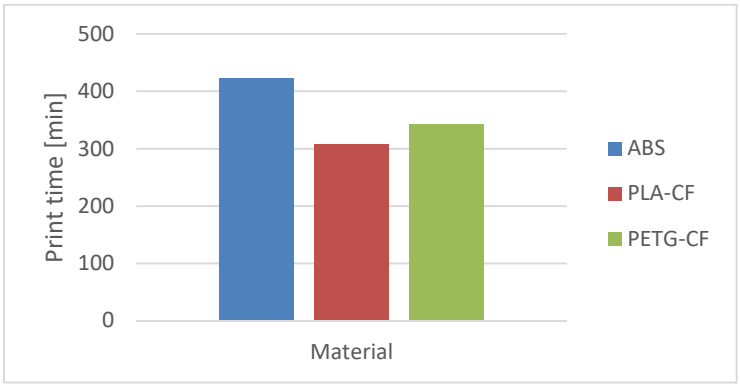


Figure 9. The print time for the phone holder models 3D printed from ABS, PLA-CF, and PETG-CF materials.

Based on the data from Table 4, the 3D printed phone holder model from PETG-CF material showing highest value of the model mass (87g) and the phone holder model from ABS material showing the lowest value (68g), are shown in Figure 10.

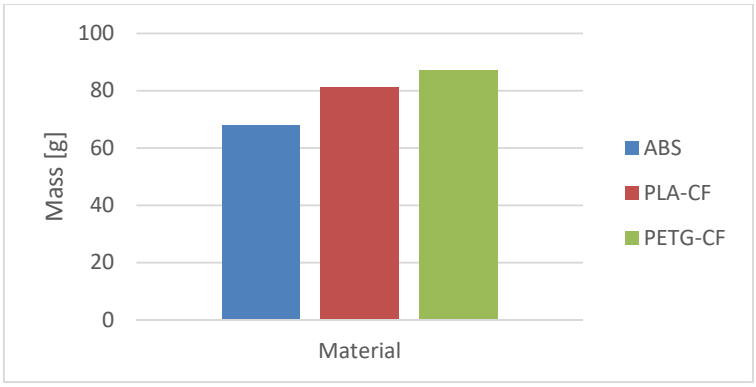


Figure 10. The mass of the 3D printed phone holder models from ABS, PLA-CF, and PETG-CF materials.

Analysing material use, it can be acquired that the 3D printed phone holder model from ABS material demonstrated the highest (31.46m) and the phone holder model from PLA-CF material the lowest (29.99m) value, see Figure 11.

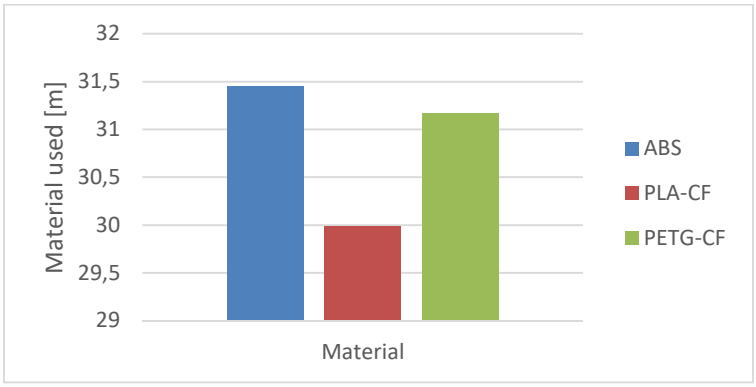


Figure 11. Material used for the 3D printed phone holder models from ABS, PLA-CF, and PETG-CF materials.

Based on the data from Table 4, the 3D printed phone holder model from PLA-CF material showing highest value of the model cost (3.97 euro) and the phone holder model from ABS material showing the lowest (1.62 euro), are represented in Figure 12.

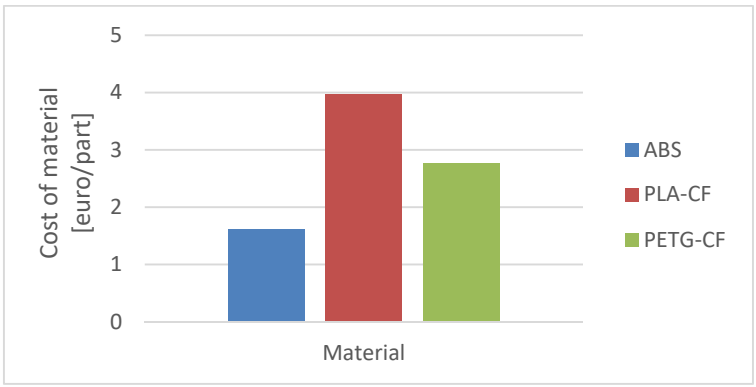


Figure 12. Cost of material for the 3D printed phone holder models from ABS, PLA-CF, and PETG-CF materials.

Based on the visual inspection of the produced models, it was determined that the model made from ABS material exhibited the highest dimensional deviations and the highest surface quality.

5. Conclusion

The paper discusses the evolution of manufacturing paradigms and focuses on the implementation of personalized production through additive manufacturing technologies. It highlights the significance of advanced technologies such as computer-aided design (CAD), simulations, 3D printing, and digital modeling in enabling personalized production. The article emphasizes the role of additive technologies, particularly fused deposition modeling (FDM), in creating complex geometric shapes and facilitating customization. The experimental section of the article presents the development and production of a phone holder using FDM 3D printing technology. Different materials, including ABS, PLA-CF, and PETG-CF, were used, and their properties and performance were analyzed. The results showed variations in print time, mass, material use, and cost among the different materials. The visual inspection indicated that the model made from ABS material exhibited the highest dimensional deviations but also

had the highest surface quality. Overall, the article highlights the transformative potential of personalized production and additive manufacturing in industrial production, offering new possibilities for innovation, creativity, and customer satisfaction.

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Application of software package CATIA v5 in modeling and construction

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Abstract. This paper describes the application of the CATIA V5 software package and shows its potential in modeling and constructing a new product. The general part describes the program package CATIA V5 and some of its modules. The CATIA V5 software package is a powerful tool that is often used by students in companies involved in production for the automotive and aerospace industries. Working with CAx applications is an important part of university education. Specifically, CAD/CAM/CAE systems at technical universities are an important area of student education. Applying and using the CATIA V5 software package greatly increases students opportunities in the labor market, especially in industrial areas. In the shown, constructed part, some additional, standard functions in 3D modeling are used, in addition to the basic functionalities of Part Design. The goal of this paper is to show the potential of the CATIA V5 software package and some of the options for creating a 3D model, followed by the import of the 3D model into the ESPRIT software package, where we program tool paths, simulate processing, and generate G-code for processing on a CNC machine.

1. Introduction

1.1. Software package CATIA V5

CATIA (Computer Aided Three-dimensional Interactive Application) is a cross-platform CAD/CAM/CAE commercial software package developed by the French company Dassault Systemes and distributed by IBM. Dassault Systemes has set a new standard with the introduction of CATIA V5, bringing dramatic improvements to system architecture and the user's work environment.

CATIA V5 is the world's leading integrated CAD/CAM/CAE program package of the new generation. It was developed on the basis of rich experience from the previous version. CATIA V5 uses state-of-the-art technology, setting standards for the future. Since the software was developed primarily for the Windows PC platform (therefore, it is not a UNIX application "ported" to the Windows PC environment), all the advantages of Windows technology are fully utilized and full compatibility with the Windows operating system and other applications (Internet, Office).

In accordance with the philosophy of Windows, as well as a special effort to bring the CAD/CAM system closer to users, CATIA V5 is characterized by ease of learning and use, providing a complete solution from design to production analysis, with the ability to connect production and other business processes such as procurement, sales, etc., through an integrated PDM solution.

Also, thanks to its technology. CATIA V5 offers the possibility of incorporating the company's know-how into the very core of the program, which increases quality and speeds up production processes.

It should be noted that CATIA V5. as a native Windows application, it is noticeably easier to learn and use than other software packages on the market. In a relatively short period of time, the user can master

most of the construction modules and other modules, such as NC, analysis, etc. The advantage of CATIA is the very simple and at the same time functional modules for NC that it has.

Figure 1. shows the initial screen of CATIA with associated menus. [1]

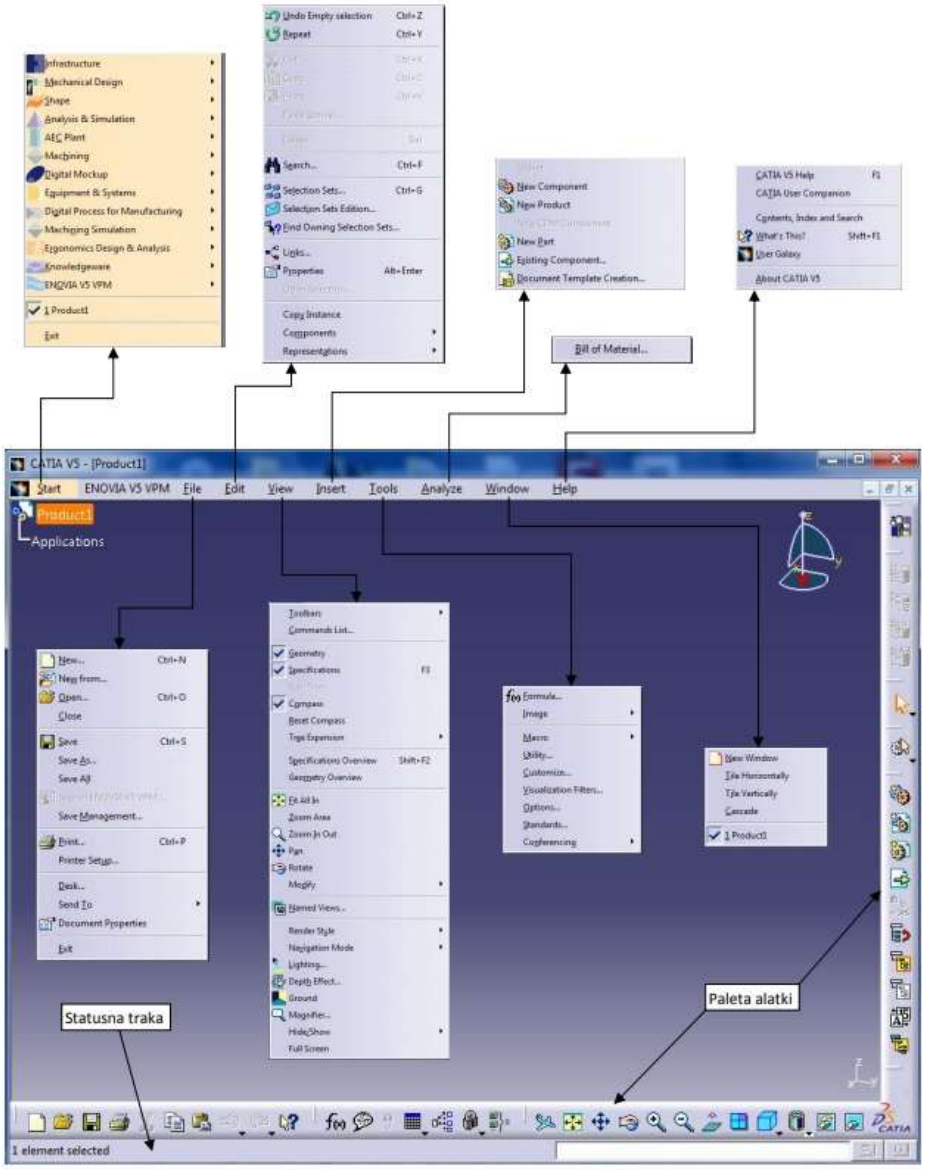


Figure 1. Initial screen when starting CATIA.

CATIA enables flexible work with solids or surfaces, and it should be mentioned also a high-quality module for 2D drawing, which is still very important for the largest number of users. After that, it's the turn of Siri's application, that is, a large number of modules, which make CATIA a comprehensive program that contains solutions for most needs of the largest number of users.

In addition to the standard construction modules, CATIA offers analysis (FEA) modules. production (CAM/NC), and a large number of specific and specialized modules, of which modules for the construction of electrical and HVAC (ventilation/air conditioning/heating) installations, modules for the design of robotic cells, composite materials, etc. should be singled out.

Furthermore, in addition to the proverbially large modeling possibilities, one of the main advantages of CATIA V5 is the CAM part, where modules from turning to 2.5-axis, 3- or 5-axis milling are available. In one sentence, Catia V5 offers extremely high sophistication with maximum simplicity and a pleasant interface, and is an ideal solution for all users, from the smallest to the most demanding. CATIA is primarily used in the automotive and aerospace industries for automotive development and airplanes. It can also be found in a wide variety of branches, including space program, industrial accessories, architecture, construction, consumer products, electronics, medicine, furniture industry and shipbuilding.

1.2.. Part design- catia v5

The Part Design module represents the starting point for creating parametric volume (solid) models in the CATIA V5 program. This application combines the power of designing using technical elements with the flexibility of an approach based on Boolean operations.

Part design enables the creation of parametric models, based on technical elements, or forms (features). Volume and surface elements are created using reference elements, sketches, sketch-based elements, ready-made elements, and transformation operations.

This hybrid approach to modeling provides the user with great flexibility in this which may or may not set constraints on the geometry. This flexibility is also reflected in the possibility of subsequent and local 3D parameterization, which helps in presenting the design idea.

1.3. Machining- catia v5

Computer-aided manufacturing refers to the use of computers in production (computer-aided manufacturing) and the use of computers to assist in the creation or management of production process control.

Technological operations of the production process are performed on computer-controlled machines, that is, processing centers (eng. Computer Numerical Control - CNC). In addition to indicating the use of computers in production. CAM also refers to the simulation of product manufacturing and the generation of control information (NC code) for numerically controlled machines.

One of the more popular CAM software on our market is CATIA V5 with integrated machining modules (Figure 2).

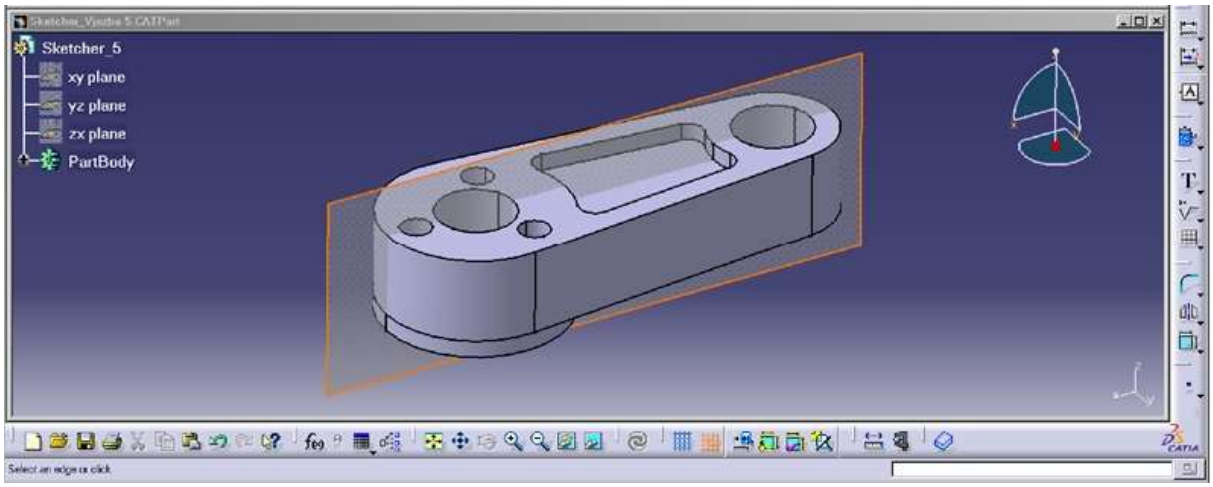


Figure 2. Preparred part for machining. [3]

Precise definition of tool paths, verification and modifications are integrated, contains the functionality of material removal simulation (accurate and realistic tool path simulation movements and machine kinematics, (Figure 3), as well as NC generation code through predefined post-processors. Machining of complete surfaces with constant control of the risk of collision between the tool handle and the workpiece, as well as advanced tool axis management strategies that include dynamic changes

in the orientation of the tool axis (tool vector normal to the given surface) and for surface machining (surface machining) and for curve machining (curve machining).

The ultimate purpose of using this type of CAM software is to reduce time. required for NC programming and the application of proven machining techniques supported by CATIA V5, all with the aim of reducing machining time by using optimized machining strategies machining types (high-speed machining).

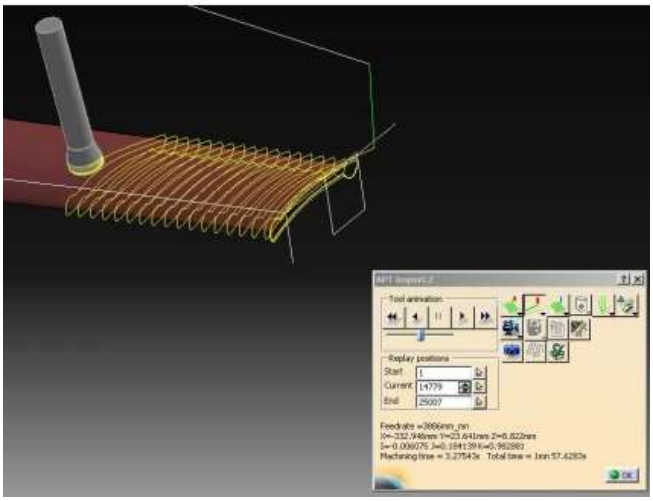
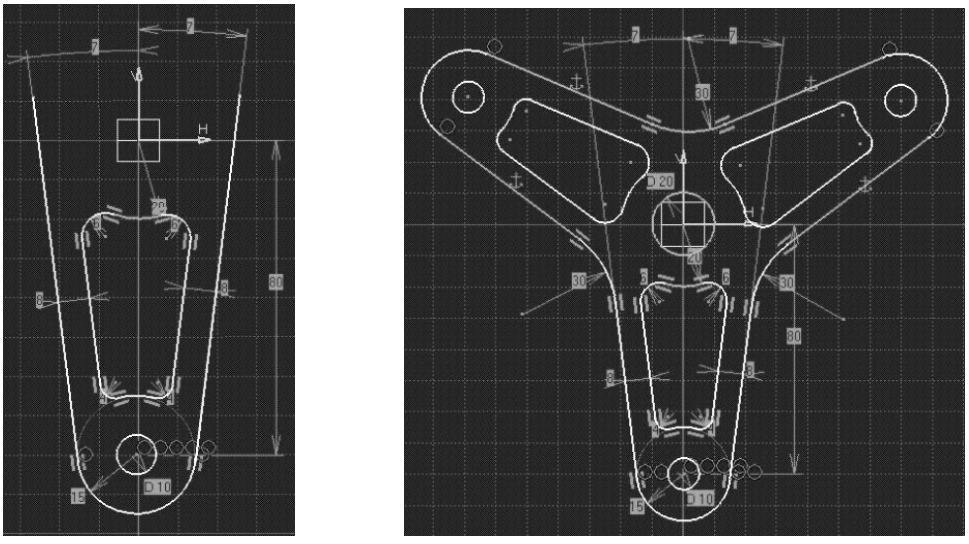


Figure 3. CATIA V5 machining, APT simulation.

2. Part Design

The Part Design command is used to create 3D models of parts. In order to get a 3D model of a part, we have to make a 2D profile using the palette of drawing tools in sketcher. In addition to drawing in the sketcher, we set constraints. This means that we can draw an approximate shape to the desired profile by adding constraints such as dimensions and geometric relationships such as parallelism, perpendicularity, etc. By using commands in sketcher, the profile shown in the following picture was obtained. [3]



a) b)

Figure 4. a) basic sketch, b) sketch after using function Rotate. [2]

Add a certain height (third dimension) to that 2D profile or rotate it around a certain axis to get a 3D part.

Which can be basic (pad, pocket, shaft, slot, hole, groove), aesthetic (filets, chamfers, draft shell thickness), reference elements (point, line, plane) and tools for transformation (translation, rotation, mirror, pattern, scale).

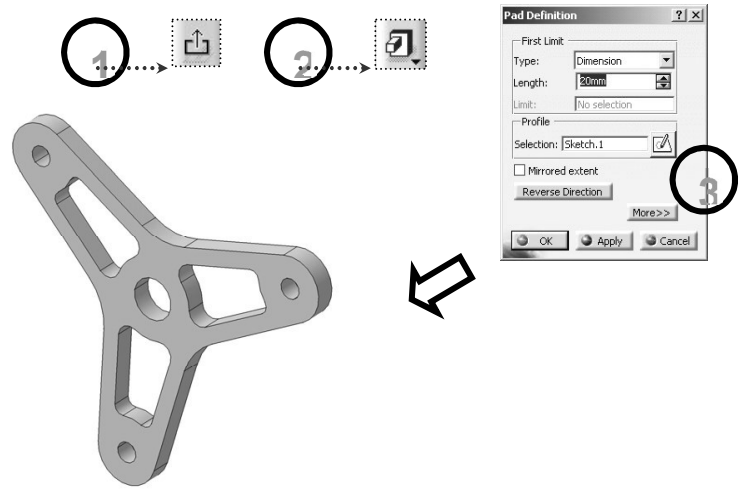


Figure 5. 3D model after use of function Pan. [2]

2.1. Assembly design

Assembly design enables the creation of assemblies of parts that we have already designed. The parts within the assembly itself are not combined into a single part, but are assembled into an assembly as a practice. Which means that certain connections should be set between the parts using constraints.

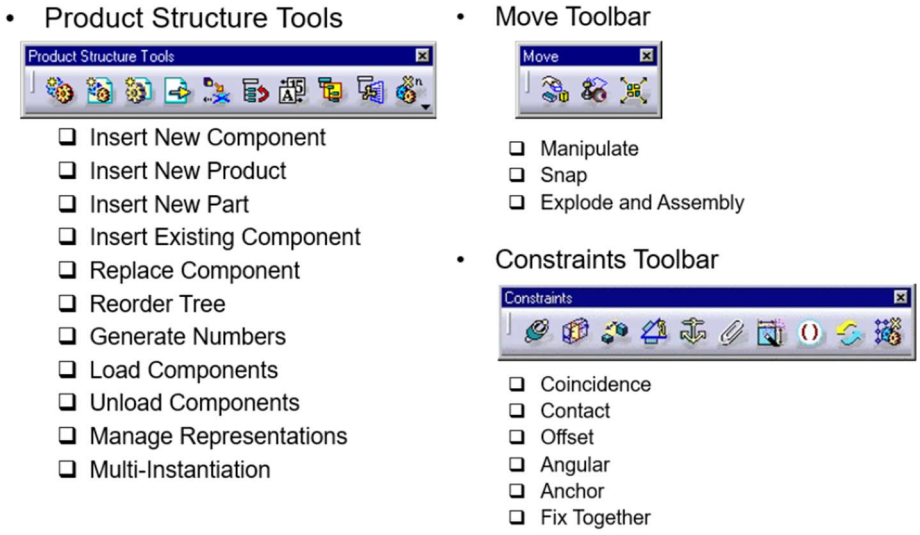


Figure 6. Toolbars whit functions. [3]

Steps to create an assembly:

1. Creating a new CATProduct document File > New > Product

2. Using the Product Structure tools to set the basic structure (part) of the scollop
3. Using the Insert Existing Component or Insert New Part commands to add existing or new parts to the assembly
4. Using constraints, set connections between different parts in the assembly.

The advantages of creating an assembly are reflected in the possibility of using standard parts in several different assemblies, when changing an individual part (part), changes to that part will also be made in the assembly, and it is possible to create a kinematic model based on the assembly and perform model analysis (in in that case the mechanism). The complete production of the assembly is shown in the Product Structure Tree, where you can see all the information about the parts, subassemblies, and the set constraints between them.

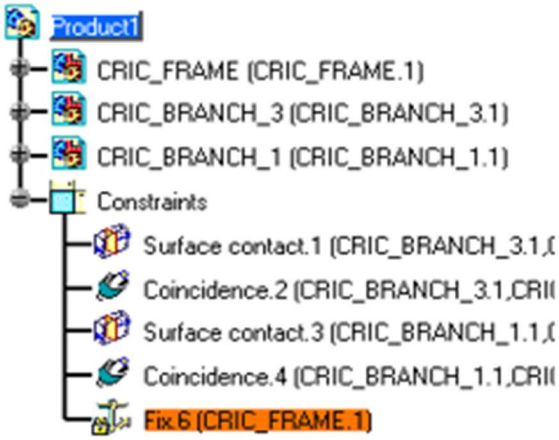


Figure 7. Product Structure Tree. [3]

Figure 4.1 shows that the assembly (Product1) consists of three separate parts (CRIC_FRAME, CRIC_BRANCH, CRIC_BRANCH_1). The geometry of the parts is not determined in the assembly, but is determined in separate parts. The connections between them (constraints) are listed below the parts that make up our assembly. [3]

2.2. Wireframe and Surface

The Wireframe and Surface options take a more traditional approach to creating 3D part models. The Wireframe option allows you to draw lines, points in space without using a sketcher based on constraints, while the Surface option creates surfaces by moving the wireframe along a certain path. The use of these two functions is most pronounced in the automotive industry for the production of certain parts of the body because it enables the production of complex surfaces in an easy way.. An example is the loft function, it requires 2 or more sections, which we make using Wireframe, and connect them with lines that will be paths along which wireframe will move.

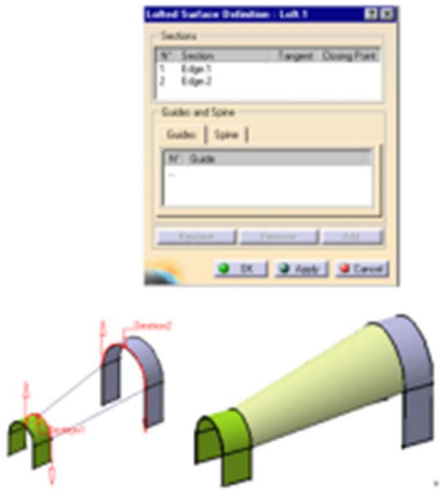


Figure 8. Function Loft. [3]

The geometry created using these functions is saved as Open Body and is not merged with the initial 3D model and we can add them as needed.

This means that the 3D model contains both Open Body and Part Boby data.

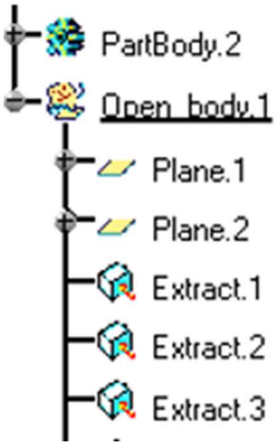


Figure 9. Specification Tree for Wireframe and Surface. [3]

Some more options that CATIA V5 offers are:

- Apply Material - allows us to determine the material from which a part is made, we choose the material from the existing range of materials offered by the program.
- Mass Properties - enables checking the properties of our piece or a specific surface.
- Generative Drafting – enables the creation of workshop drawings for an assembly or part that we have as a 3D model.
- Interactive Drafting – enables drawing workshop drawings without creating 3D models.
- Generative Part Structure Analysis - enables stress and fatigue analysis of a piece or assembly.

3. Conclusion

The CATIA VS software package is a powerful tool often used by students in automotive and aerospace companies. CATIA enables flexible work with solid materials or surfaces, and a high- quality 2D

drawing module should be mentioned, which is very important for the largest number of users. In addition to the standard design modules, CATIA offers an Analysis (FEA) module, speeds up the production process. Production (CAM/NC), a large number of specific and specialized modules, of which there are modules for building electrical and HVAC (ventilation/air conditioning/heating) installations, modules for designing robotic cells, composite materials, etc. should be singled out. The Part Design module is the starting point for creating parametric volume (solid) models in CATIA V5. This application combines the power of designing using technical elements with the flexibility of an approach based on Boolean operations. In addition to model design, CATIA V5 also offers options such as assembly design, production of workshop drawings from models, drawing drawings without models, stress and fatigue analysis of materials and much more. In one sentence, CATIA V5 offers extremely high sophistication with maximum simplicity, has a lot of use but also requires a lot of experience because there are a lot of features to explore.

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Analysis of the surface roughness on the notched element machined on the universal lathe machine and CNC turning machine

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Abstract. In this paper, the main focus is the analysis of surface roughness. Analysis of surface roughness was done on the example of the notched element that was made using the process of machining by removing material. Specifically, two different machines were used: a universal lathe machine and a *CNC* turning machine. In addition to the analysis of different machines, the influence of the selection of the right cutting tool, the cutting insert, was analyzed as one of the factors on the quality of the machined surface. For roughness analysis, three roughness parameters were used in this paper: R_a, R_z, and R_{max}. Results from this analysis have shown how significant is the right selection of the machine and the cutting tool, as they have an important role in surface roughness quality.

1. Introduction

Technologies that are based on a process of machining by removing material have wide use because of their favorable characteristics. Information that at least 70% of total production is production based on a process of machining by removing material, confirms the fact that approximately 85% of the machines in the world are machines for the process of machining by removing a material [4]. As is known, the machining process is carried out by penetrating the cutting insert into the material that is being machined. The result of that process is a separation of a layer of material that is removed from the working area of the machine, which has an impact on the quality of the surface roughness of the notched element. The main goal of every production today is to achieve the shortest possible time, from receiving the order, until having a finished product, while making sure the quality expectations are at the desired level. Machining time and quality of a product are the main factors of successful production. With an example shown in this paper, surface roughness analysis of the notched element has been analyzed, which has been machined on a universal lathe machine and a *CNC* turning machine. Besides using a different machine, different cutting tools were also used.

2. Roughness

Roughness is defined as a microgeometric irregularity of the surface, i.e. unevenness on a small reference length of a certain direction of the surface [3]. The surface roughness depends on the shape of the cutting tool, cutting tool edges condition, the wear of the cutting tool edges, vibrations, deposits, etc. There are more than thirty parameters that are being used to track the roughness of some surfaces.

In this paper, three main parameters were used: R_a – known as relative to a mean reference line, R_z – known as the height difference between the five highest peaks and five lowest valleys and R_{max} – known as the maximum height of the surface roughness [1].
Equation (1) shows how to calculate R_a roughness parameter and eqation (2) shows how to calculate R_{max} roughness parameter.

$$R_a = \frac{1}{l}\int_0^l |y(x)|dx \tag{1}$$

$$R_z = \frac{R_1+R_3+R_5+R_7+R_9}{5} - \frac{R_2+R_4+R_6+R_8+R_{10}}{5} \tag{2}$$

Figure 1 shows an example of choosing and marking the five highest peaks and the lowest valleys of the profile of some specific surface [3].

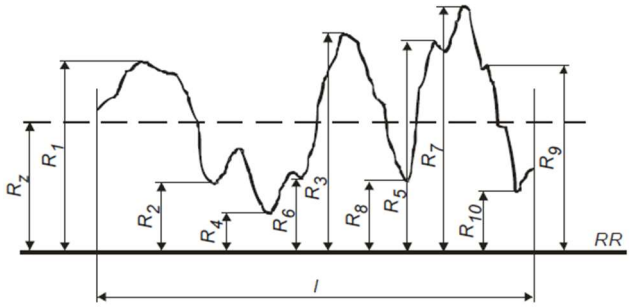


Figure 1. The five highest peaks and the lowest valleys of some specific surface.

Measuring the roughness has been made on the machine for roughness measurement, following applicable standards. Figure 2 shows an example of the machine from a producer "Mahr", type MarSurf XR1 [2].

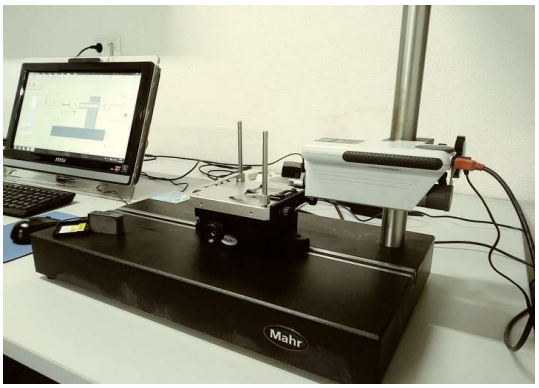


Figure 2. Measuring device "Mahr" MarSurf XR1.

The surface roughness of the notched element was measured using the device from figure 2.

3. Process of machining a notched element

The notched element was made by using two different machines: a universal lathe machine and a *CNC* turning machine. Figure 3 shows the notched element designed in *SolidWorks* software.

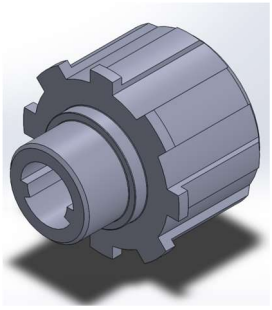


Figure 3 Notched element designed in *SolidWorks* software.

The material that the notched element was made from is an aluminum alloy EN AW–6060 T6 (AlMgSi0,5 F22). The chemical composition of this alloy is shown in table 1[5].

Table 1. Chemical composition of the alloy EN AW-6060 T6 (AlMgSi0,5 F22).

Chemical composition of the alloy EN AW-6060 T6 (AlMgSi0,5 F22)		
Chemical element		Representation (%)
Si		0,3 - 0,6
Fe		0,1 - 0,3
Cu		≤ 0,1
Mn		≤ 0,1
Mg		0,35 - 0,6
Cr		≤ 0,05
Zn		≤ 0,15
Ti		≤ 0,1
other	individually	≤ 0,05
	total	≤ 0,15

Table 2 shows the mechanical characteristics of the alloy EN AW-6060 T6 (AlMgSi0,5 F22) [6].

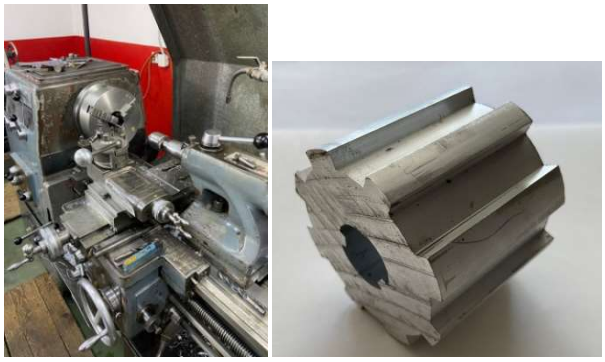
Table 2. The mechanical characteristics of the alloy EN AW-6060 T6 (AlMgSi0,5 F22).

Mechanical characteristics of the alloy EN AW-6060 T6 **(**AlMgSi0,5 F22)	
Tensile strength – R_m, N/mm^2	190
Yield strength – R_e, N/mm^2	150
Elongation, %	6
Hardness, HB	70

The most common use of this material is in the aviation industry, electronic and precise instruments, doors and windows, architecture and food industry, etc.

3.1. Process of machining a notched element on a universal lathe machine

The machine that was used to make a notched element on a universal lathe machine was "Meuser" MOL. The mentioned machine is shown in figure 4.



a) b)

Figure 4. Universal lathe machine a) and an initial piece b).

Figure 5 shows a final look at the notched element after the process of machining on a universal lathe machine.

Figure 5. Machined notched element
on a universal lathe machine.

3.2. Process of machining notched element on a CNC turning machine

The machine that was used to machine a notched element, was a *CNC* turning machine from an "EMCO" producer Turn465-C. "EMCO" Turn465-C is shown in figure 6.

a) b)

Figure 6. "EMCO" Turn465-C turning machine a) and a notched element
shown in stages of machining b).

While the notched element was in the process of machining, two different cutting tools were used. That was done to show how important is the right selection of the cutting tool on the surface roughness quality.

3.2.1. *Process of machining a notched element with a cutting tool "Widia" VBMT160404 TTI15*
Figure 7 shows a cutting tool "Widia" VBMT160404 TTI15 and a notched element that was machined with the mentioned cutting tool.

a) b)

Figure 7. Cutting tool "Widia" VBMT160404 TTI15 (a) and a notched element (b).

On this finished notched element, there were some surface irregularities noticed. They require manual removal and that requires additional time spent. Surface irregularities have a direct impact on the quality and functionality of the final product in a montage or some assembly.

3.2.2. *Process of machining a notched element with a cutting tool "DiaEdge" VCGT160404-AZHTi10*
The machine that was used for machining a notched element was also a *CNC* turning machine "EMCO" Turn 465–C. In this case, a different cutting tool was used, by a producer "DiaEdge" VCGT160404–AZ HTi10, figure 8.

a) b)

Figure 8. Cutting tool "DiaEdge" VCGT160404-AZHTi10 (a) and a notched element (b).

The notched element machined with a cutting tool "DiaEdge" VCGT160404–AZ HTi10 has a better-machined surface and there is no appearance of surface irregularities.
It is important to mention that only this cutting tool was used in a process of machining the notched element on a universal lathe machine.

4. Process of measuring roughness and the results of the surface roughness on the notched element

The process of measuring the roughness of a machined surface of the notched element was done in a company "ZAH" d.o.o. Bosanska Krupa, on a measuring device "Mahr" MarSurf XR1, figure 9.

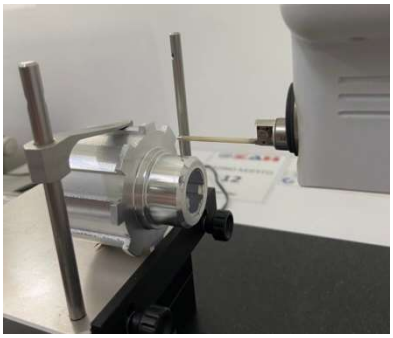
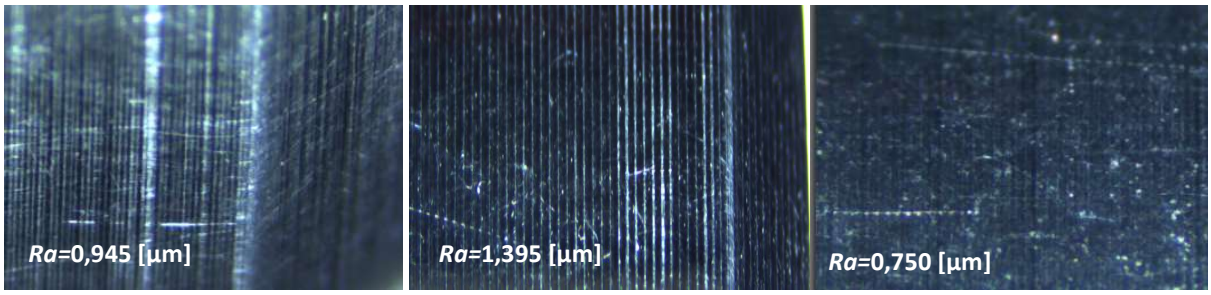


Figure 9. Notched element in the process of surface roughness measurement on the MarSurf XR1 device.

Except that the roughness from the notched element was taken, in the same company, pictures from the measured surface were taken.

4.1. Results from the process of measuring roughness

Figure 10 displays realistic pictures of a machined surfaces of the notched element, which machining took place on a universal lathe machine (a) and a *CNC* turning machine with cutting tools: VBMT160404 TTI15 (b) and VCGT160404–AZ HTi10 (c).



a) b) c)

Figure 10. The machined surface of the notched element machined on a universal lathe machine (*a*) and a *CNC* turning machine (*b*,*c*).

Results from the roughness measurements are indicating that the best quality machined surface is the one machined on a *CNC* turning machine with a VCGT160404–AZ HTi10 cutting tool. That can be also confirmed by looking at the three displays in figure 10. Machining on a *CNC* turning machine with this cutting tool provides the least visible cutting tool marks. Table 3 contains the results from the surface roughness measurements for the chosen roughness parameters.

Table 3. Results of the surface roughness measurements of the notched element.

Results of the surface roughness measurement of the notched element				
Measuring device	Roughness parameter, μm	Machining system		
		Universal lathe machine	*CNC* turning machine	
			Cutting tool VBMT16404 TTI15	Cutting tool VCGT160404-AZ HTi10
"Mahr" MarSurf XR1	R_a	0,945	1,395	0,750
	R_z	6,224	6,087	4,092
	R_{max}	7,159	6,588	4,630

5. Conclusion

According to the results of the roughness measurements, machining on a *CNC* turning machine with the right cutting tool for a material that is machining, has the best quality of the machined surface. Besides choosing the right cutting tool, some extra parameters have an impact on the obtained roughness (tool radius, feed rate, depth of cut, auxiliary movement speed, etc.). This does not have a meaning that a good machined surface quality can not be achieved on a universal lathe machine. However, the experience of the machine operator has a great impact on the success of machining. Also, characteristics of the cutting tool VCGT160404-AZ HTi10 had a great impact on the success rate of the quality of the machined surface of the notched element. This cutting tool is intended for aluminum and aluminum alloy machining, which refers to the material of the coating, the shape of the burner, the reinforced edges of the cutting tool, etc.

6. References

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Sealing of hydraulic blocks holes with threaded pins

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Abstract. In many engineering applications, hydraulic systems of various sizes are present. The most ideal hydraulic system should have the least possible weight and volume. This requirement drives the development of hydraulic systems towards optimal mass and size optimization. In many hydraulic systems, hydraulic components are combined into hydraulic blocks, especially in the field of mobile hydraulics, with the aim of achieving this goal. Closing and sealing service holes or required drillings for manufacturing pose a challenge in the design and production of hydraulic blocks. This article presents existing methods for closing and sealing hydraulic block holes, along with the test results of using threaded pins according to the SIST ISO 4026 standard in combination with sealing compound.

1. Introduction

In mechanical engineering and other technical industries, whether it's construction and agricultural machinery or large-scale systems like factories, there is a noticeable increase in the use of power-controlled hydraulics, which differ mainly in their power, size, and compactness. While heavier and larger systems can be afforded in industrial facilities, it becomes more challenging in mobile hydraulics where we are largely limited by the weight of the system. In order to optimize space and weight, hydraulic blocks are therefore employed in mobile hydraulics, into which individual hydraulic components are integrated. Hydraulic blocks are typically made from metallic materials such as steel and aluminium, with hydraulic conduits and threaded connections for sensors, hydraulic valves, accumulators, and other components. Hydraulic blocks are largely manufactured through drilling and milling, which, due to technological limitations, restricts the optimization possibilities of hydraulic blocks. Due to these technological constraints, technical holes appear in hydraulic blocks alongside the drilled holes that serve as hydraulic conduits. These technical holes are necessary for the production of hydraulic blocks and do not have any functional use or are intended for subsequent connection of additional elements. Therefore, they need to be properly sealed after production to prevent hydraulic fluid leakage.

Research on closing and sealing these holes dates back to the early development of hydraulic blocks, primarily with the aim of finding cheaper and more reliable methods of closing and sealing hydraulic blocks. Throughout the evolutionary development of hydraulic blocks, several effective sealing methods have been developed (Figure 1), such as sealing with sealing plugs (Figure 1a), expansion plugs (Figure 1b), or welding of threaded plugs [1-4].

a) b)

Figure 1. a) Sealing plug with gasket [1], b) Expansion plug [2].

Each of the listed closing systems has its own advantages and disadvantages. The sealing plug with gasket has the advantage of easy opening of the technical borehole for subsequent use or servicing of the hydraulic block. However, a drawback of the sealing plug is that it requires a relatively large amount of space, which is often limited due to the optimization of hydraulic blocks. On the other hand, expansion plugs and threaded plugs secured by welding have the advantage of requiring very little space for installation. The drawback of this sealing method, however, is that the borehole cannot be easily accessed for servicing or subsequent modifications, as it requires drilling to remove the plugs, which is often impractical in the field. Additionally, the hydraulic block may be damaged during the removal of such seals.

Furthermore, this article presents existing methods of closing and sealing hydraulic blocks and introduces research on the possibility of using threaded pins according to the SIST ISO 4026 (DIN 913) standard in combination with sealing paste for the closure and sealing of hydraulic blocks.

Based on the research objectives and a review of relevant literature [2-11] on the theory of leakage through clearances, we have formulated the following hypotheses:

- The length of the threaded pin has an impact on sealing with sealing paste (a longer thread length results in less leakage).
- The material of the threaded pins affects the adherence of the sealing paste and consequently the sealing of the joint (sealing paste adheres less effectively to honed threaded pins due to the honing process).
- The tightening torque has an effect on the sealing of the joint (higher tightening torque leads to better sealing).
- The combination of tightening torque and sealing paste can result in displacement of the sealing paste and thus poorer sealing.
- The diameter of the threaded pin influences the sealing of the joint (larger diameter results in higher leakage).

2. Theoretical background

A functional and efficient hydraulic system is composed of hydraulic components. The advantage of a hydraulic system is its ability to transmit large forces and moments while having low inertial forces, resulting in reduced vibrations and impacts.

Clearances between elements in hydraulic components form the basis of a hydrostatic hydraulic system and its components. In many hydraulic components of power-control hydraulics, traditional elastic sealing elements such as O-rings and radial shaft seals are not used. Instead, a low clearance gap is employed to minimize leakage between the elements. This gap reduction helps to minimize leakage and allows for the movement of elements relative to each other, even at higher speeds. It also accommodates the expansion of elements due to thermal expansion of the material. Another advantage of the clearance is its allowance for deviations from ideal shapes in real element configurations.

The size of the clearance significantly affects the volumetric efficiency of the hydraulic component and, consequently, the overall efficiency of the hydraulic device (larger clearance results in greater leakage and lower efficiency). Clearances between elements in hydraulic components typically range between 2 □m and 10 □m. While clearances are common in active hydraulic system elements, they are rarely found in passive or auxiliary hydraulic components such as reservoirs, filters, pipelines, etc., [7-10].

Leakage through the thread of a threaded pin can be theoretically defined as leakage through clearances or leakage through labyrinth seals or as the flow of fluid between two flat plates, as shown in Figure 2.

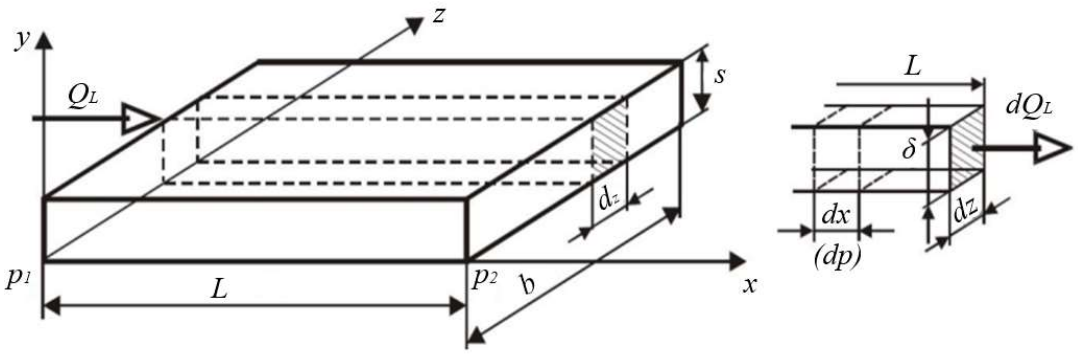


Figure 2. An example of fluid flow between two flat plates [11].

The mathematical expression of fluid flow between two flat plates is represented by equation (1).

$$\frac{dp}{dx} = -\frac{12 \cdot \rho \cdot \nu}{\delta^3} \cdot \frac{dQ_L}{dz} \tag{1}$$

Where: the clearance height (□) is in meters, the kinematic viscosity (□) is in m^2/s and the fluid density (□) is in kg/m^3.

Through the clearance, a pressure difference occurs, where $p_1 > p_2$, from which we can express the pressure change as $\Delta p = p_1 - p_2$.

For the sake of simplicity, let's assume that streamlines within the laminar flow are parallel, so the pressure drop for each infinitesimal width element of the flow (dz), is equal to each other [11]. The solution of equation (1) enables the representation of pressure change across the clearance and determination of the flow of hydraulic fluid due to leakage through the clearance, as depicted in equation (2) [7].

$$dQ_L = \frac{\Delta p \cdot \delta^3}{12 \cdot \rho \cdot \nu \cdot L} \cdot dz \tag{2}$$

In the case when the clearance remains constant and does not change, the equation can be expressed in the form of equation (3). Where d represents the width of the gap, δ denotes the height of the gap, and L represents the length of the gap [11].

$$dQ_L = \frac{\Delta p \cdot d \cdot \delta^3}{12 \cdot \rho \cdot \nu \cdot L} \tag{3}$$

In hydraulics, leakage between two flat surfaces is typically not encountered. However, leakage through circumferential gaps, which occur between the piston and the bore, is very common. To calculate the leakage in circumferential gaps for pistons that are concentric with the bore, we assume that the height of the gap δ is determined by equation (4), as shown in Figure 3.

$$\delta = r_i - r_b = \frac{D_i - D_b}{2} \tag{4}$$

The width of the gap, denoted as dz in equation (2), is expressed for circumferential gaps by equation (5) and represents a differential length of the arc.

$$dz = \frac{D_{sr} \cdot d_\vartheta}{2} \tag{5}$$

Whereby the average diameter in the circumferential gap is determined according to equation (6):

$$D_{sr} = \frac{D_i + D_b}{2} \tag{6}$$

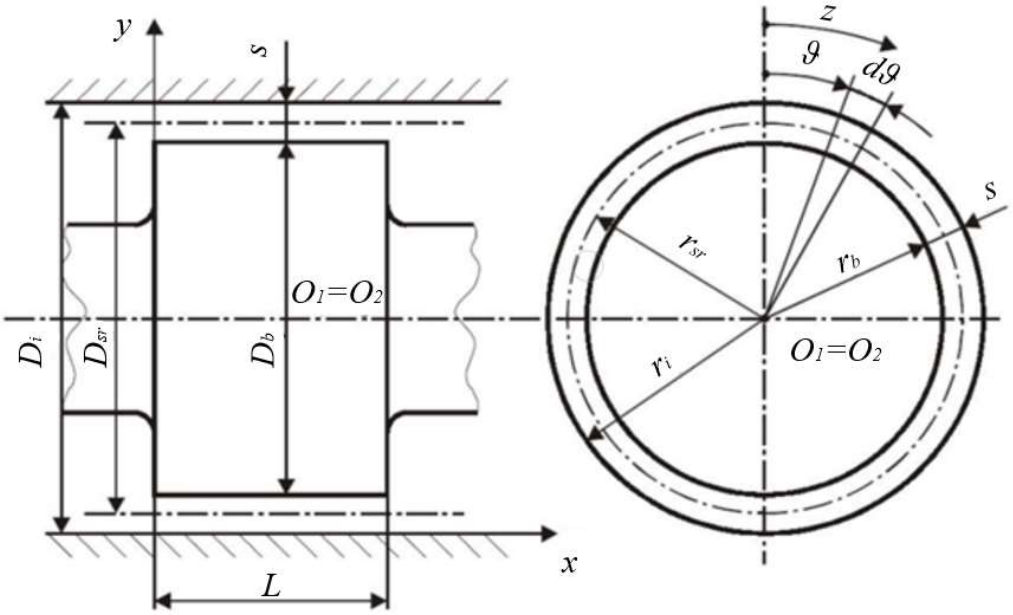


Figure 3. Piston concentric and centered within the bore [7]

The final form of equation (2), after derivation, for calculating the internal leakage through circumferential gaps in the case of a piston being coaxially and centrally positioned within the bore, is presented as equation (7):

$$dQ_L = \frac{\pi \cdot \Delta p \cdot D_{sr} \cdot s^3}{12 \cdot \rho \cdot \nu \cdot L} \tag{7}$$

In the case where the piston position is eccentric with respect to the bore position, as shown in Figure 4, it is necessary to consider the eccentricity factor.

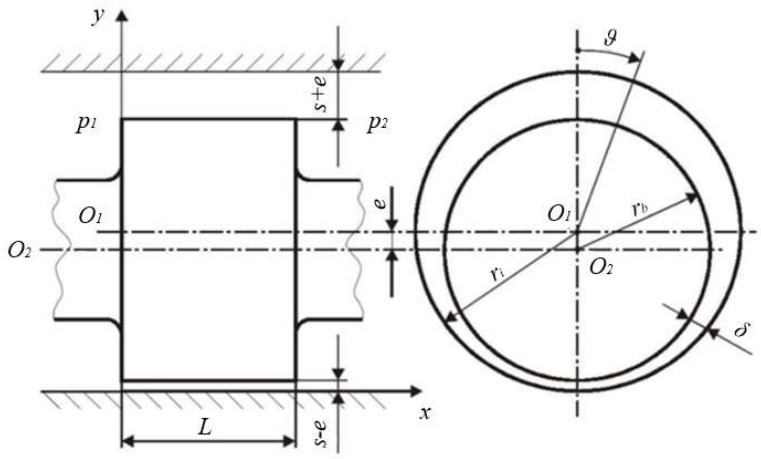


Figure 4. Eccentric position of the piston within the bore [7].

In this case, the leakage is calculated using equation (8), and the eccentricity factor is determined using equation (9) [7]:

$$dQ_L = \frac{\pi \cdot \Delta p \cdot D_{sr} \cdot s^3}{12 \cdot \rho \cdot \nu \cdot L} \cdot f_{c/eksc} \tag{8}$$

$$f_{c/eksc} = 1 + 1{,}5 \cdot \left(\left(\frac{e}{s}\right)^2\right) \tag{9}$$

The eccentricity factor is within the range of $1 \leq f_{c/eksc} \geq 2{,}5$, where $f_{c/eksc} = 1$ for a centrally positioned piston in the bore, and $f_{c/eksc} = 2{,}5$ for maximum eccentricity of the piston in the bore.

Figure 5 illustrates the geometric conditions when the piston is eccentric in the bore, which form the basis of the equation for calculating the eccentricity factor (9).

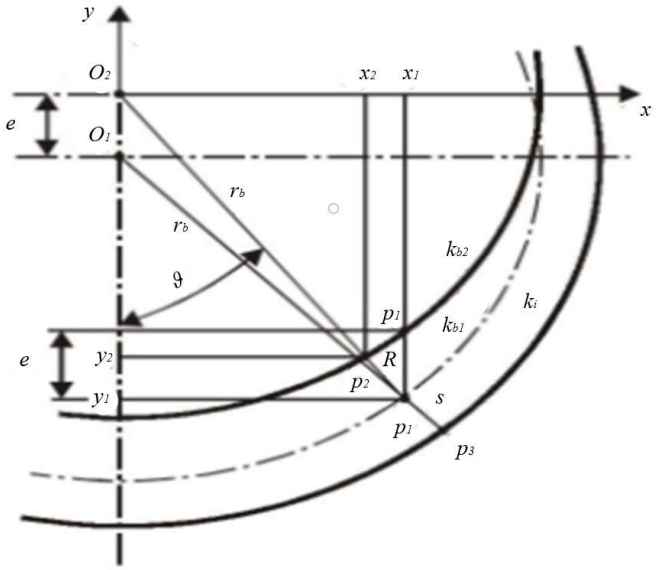


Figure 5. The geometric conditions in the case of piston eccentricity for calculating the eccentricity factor [7].

Reducing the leakage through the gap can also be improved, especially for fluids with lower viscosity, by incorporating channels on the piston. These channels promote the formation of turbulent flow during fluid passage, resulting in additional pressure drop across the gap and consequently reducing leakage. The operating principle of turbulent flow in the channels is similar to that of a labyrinth seal [7].

The use of channels on the piston offers additional advantages beyond leakage reduction. The presence of grooves helps normalize the pressure distribution due to the pressure drop, leading to improved piston centring within the bore. Furthermore, it reduces the radial pressure on the piston, particularly when the groove width exceeds the groove height [12].

3. Methodology

3.1. Experiment planning

The test design process began with determining the fundamental principles of the testing procedure. It was established that the test facility would require a hydraulic pump, a pressure gauge for measuring pressure, and hydraulic fluid provided by the manufacturer OLMA, specifically labelled as ISO VG 46.

During the test planning phase, specific physical quantities were determined to be monitored during the experiment, namely, the pressure in the system in MPa and the leakage rate in l/s or the number of drops per minute.

Before conducting the test apparatus and samples, a parameter list was prepared for research purposes to define the influences affecting the sealing of threaded plugs in hydraulic blocks. Based on these parameters, a measurement matrix was developed, as shown in Figure 6:

- Test pressure levels: 150, 250, and 350 bar,
- Type of threaded pins: SIST ISO 4026 (DIN913),
- Thread sizes: M6, M10, and M14,
- Length of threads: 10, 16, and 20 mm,
- Material of threaded pins: Burnished and stainless steel,
- Hydraulic fluid: OLMA ISO VG 46 mineral oil,
- Torque applied during tightening,
- Sealing method: With and without sealant paste.

Based on the measurement matrix, we determined that a minimum of nine test specimens needed to be manufactured. However, to ensure measurement repeatability, we produced three identical pieces for each individual test specimen, resulting in a total of 27 test specimens.

After consulting with adhesive and sealant paste manufacturers, we selected the KemisKOL sealant paste with the designation T333 based on their recommendation. This paste was deemed most suitable for our application due to its resistance to high pressures, wide operating temperature range, and compatibility with oils and derivatives. Additionally, we chose an appropriate degreaser, KemisSPREJ, specifically the A degreaser, which is compatible with the KemisKOL sealant paste.

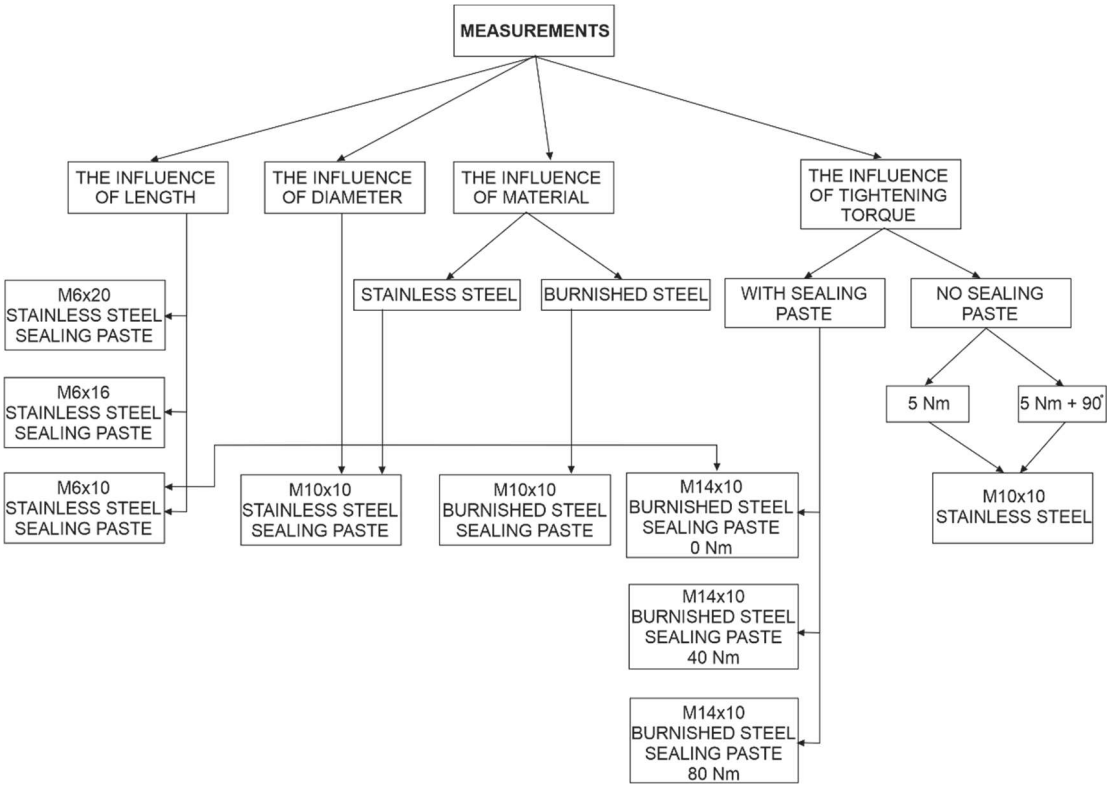


Figure 6. Matrix of measurements [7].

3.2. Test specimen and test facility design

In the initial phase, we determined pressure and leakage as two physical quantities to be monitored and measured. Based on the hydraulic pump available in the laboratory and the sealing paste's capability, which, according to the manufacturer's data, can withstand loads up to 400 bar, we defined the measurement range. The measurements were conducted at pressure levels of 150 bar, 250 bar, and 350 bar, while monitoring changes on the test specimen and measuring the leakage of hydraulic fluid in a measuring cylinder.

The test specimens were cylindrical in shape with a bore, featuring a threaded hydraulic connection on one side and a threaded plug according to SIST ISO 4026 on the other side, as shown in Figure 7, representing a simplified hydraulic block. We produced 27 pieces of these simplified hydraulic blocks with M6, M10, and M14 threads.

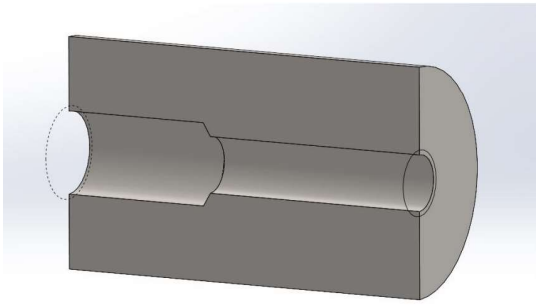


Figure 7. 3D model of the test specimen [13].

We manufactured the simplified hydraulic blocks from improved steel with the designation 1.7131 (16MnCr5) using traditional lathe machining. Prior to producing the test specimens, we conducted

preventive inspections on the hydraulic blocks in accordance with Eq.10 since they will be subjected to pressures up to 350 bar. We obtained the tensile strength data (450 MPa) from Kraut's Engineering Handbook [14] and, following consultation, determined a safety factor of 1,5. In this case, the applied pressures can reach up to 350 bar.

$$a = \frac{\Delta p \cdot d_N}{2\frac{\sigma_v}{v} \cdot 1 - \Delta p} \tag{10}$$

a wall thickness in mm,
Δp pressure difference in MPa,
d_N maximum internal diameter in mm,
σ_v yield stress in MPa,
v safety factor.

Figure 8 illustrates all the simplified hydraulic blocks that we manufactured for the testing purposes.

Figure 8. The manufactured simplified hydraulic blocks [13].

The selected dowel pins were manufactured according to the SIST ISO 4026 standard and are shown in Figure 9.

In the simplified hydraulic blocks, we installed threaded dowel pins. Initially, we conducted measurements of the baseline leakage through the threads without any sealing compound. Then, we gradually increased the tightening torque on the threads and repeated the tests to evaluate the influence of the tightening torque on the sealing of the threaded dowel pins.

In the second phase of the test, we thoroughly cleaned and degreased the hydraulic blocks, and during the assembly of the dowel pins, we applied a sealing compound according to the manufacturer's instructions.

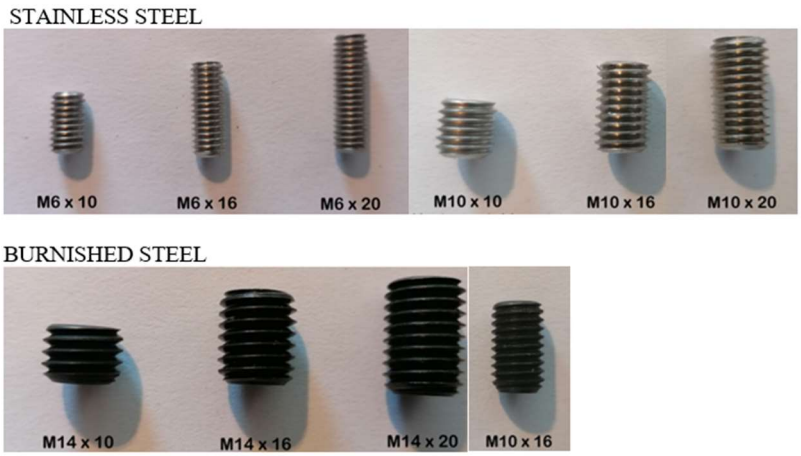
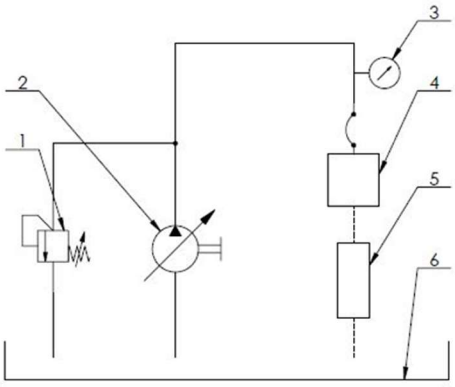


Figure 9. Selected threaded dowel pins according to SIST ISO 4026 [13].

For the purposes of the test facility, we utilized the following:

- An existing test bench with a hydraulic pump, which we equipped with a pressure gauge and a ball valve.
- To control the pressure in the system, we employed a safety valve with an adjustable spring.
- For securing the test specimens, we fabricated a simple holder using sheet metal strips and clamps for the tubing.
- To measure the leakage, we utilized measuring cylinders in two sizes: 500 ml and 2000 ml.

Figure 10 illustrates the diagram of the hydraulic system with a description of its components, as well as the holder for hydraulic blocks.



LEGEND:

1. safety valve
2. variable displacement pump
3. manometer
4. test specimen
5. measuring cylinder
6. oil tank

Figure 10. Illustration of the holder for mounting hydraulic blocks (on the right) and the hydraulic system diagram of the test bench (on the left) [13].

3.3. Course of experiment

We conducted two phases of measurements for all test specimens. The first phase was purely for control purposes, where we simply threaded the threaded pins into the simplified hydraulic blocks without using any sealant paste or other seals. In the second phase, which involved the main measurements, we monitored the influence of sealant paste and various parameters that could affect the sealing.

Each individual test specimen was installed in a clamp within the holder and subjected to the appropriate pressure (150 bar), while measuring the leakage in liters per minute (l/min). When the fluid leakage was minimal, we continued the measurement until we could measure the leakage in drops per second (drops/s). In cases where the hydraulic block was subjected to a 10-minute load without any signs of leakage, we could conclude that the joint was sealing properly. We repeated the measurements at elevated pressures (250 bar and 350 bar). Throughout the measurements, we also monitored the oil temperature within the range of 45 to 55 °C.

We conducted three measurements for each test specimen. An example of the leakage measurement procedure is shown in Figure 11.

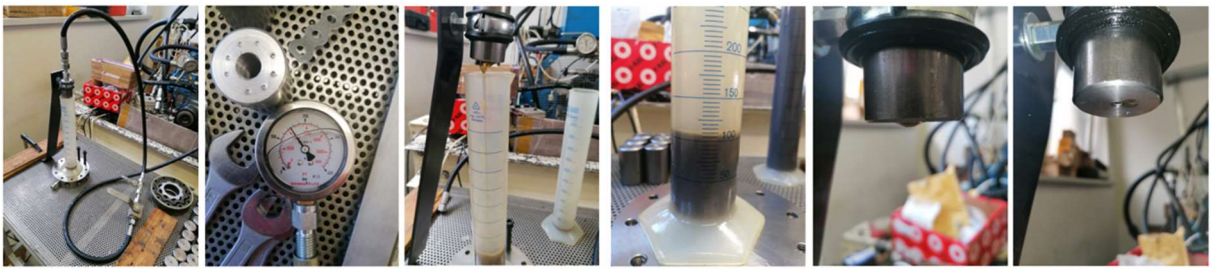


Figure 11. Leakage measurement.

4. Results and discussion

This section presents the results of the conducted tests. The tests are divided into two main groups: the control measurement and the main measurement.

4.1. The control measurement results

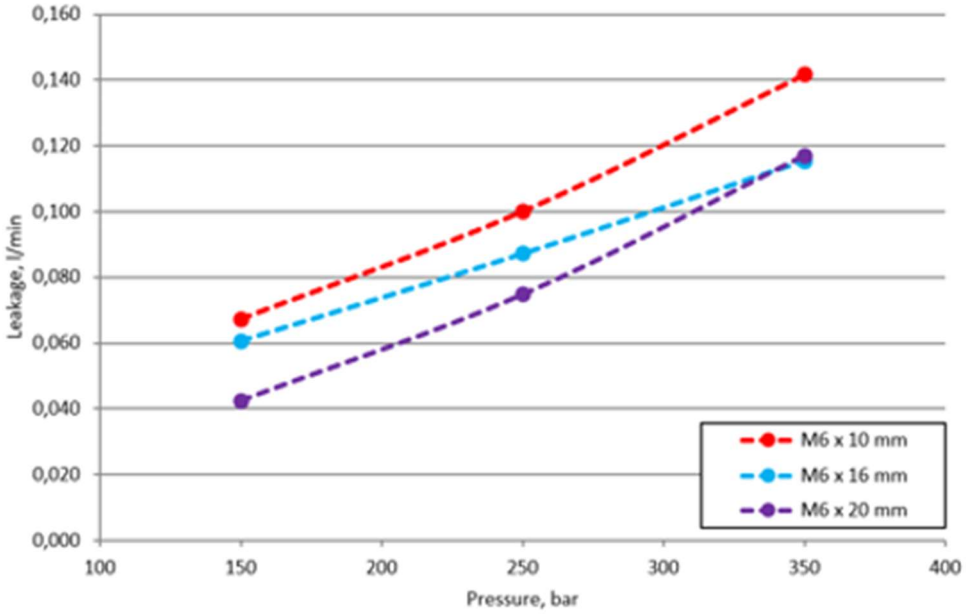
During the control measurement, there were no major surprises. As anticipated, all test samples showed excessive leakage as no sealing paste was applied. Certain trends were observed from the control measurements and the obtained results, which could influence the sealing quality. To ensure test reproducibility, three measurements were performed for each case on three identical specimens (same material, same thread, and equal plug length).

The results of the control measurement without increasing the tightening torque and without the use of sealing paste are presented in Table 1 and shown in Figure 12.

Table 1. The control measurement results [13].

Thread size mm/pin Length mm	Pressure bar	Leakage l/min	Pressure bar	Leakage l/min	Pressure bar	Leakage l/min
6/10	150	0,067	250	0,100	350	0,142
6/16	150	0,061	250	0,087	350	0,115
6/20	150	0,042	250	0,075	350	0,117
10/10	150	0,424	250	0,636	350	0,850
10/16	150	0,264	250	0,422	350	0,614
10/20	150	0,289	250	0,468	350	0,639
14/10	150	1,234	250	1,946	350	2,637
14/16	150	0,894	250	1,307	350	1,739
14/20	150	0,321	250	0,525	350	0,718

Based on the thread design, one could expect leakage similar to that of labyrinth seals. Additionally, by examining the results from Table 1, it is possible to observe the influence of pressure, thread length, and thread diameter on the leakage. Increasing the thread length leads to a reduction in leakage. On the other hand, increasing the diameter of the pin results in increased leakage, primarily due to the larger thread pitch and consequently increased clearance within the thread.



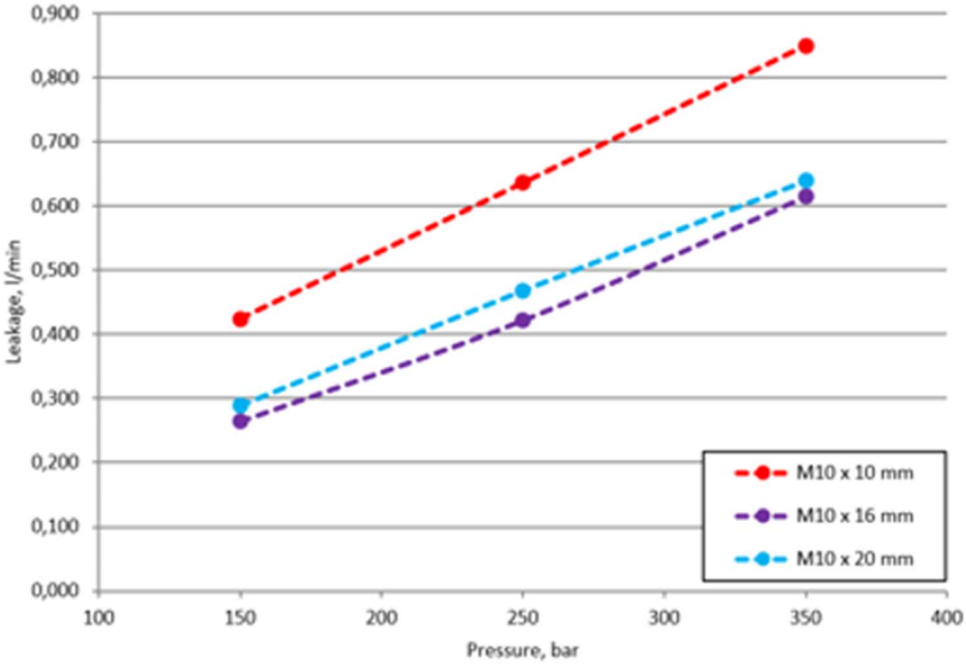


Figure 12. Cont.

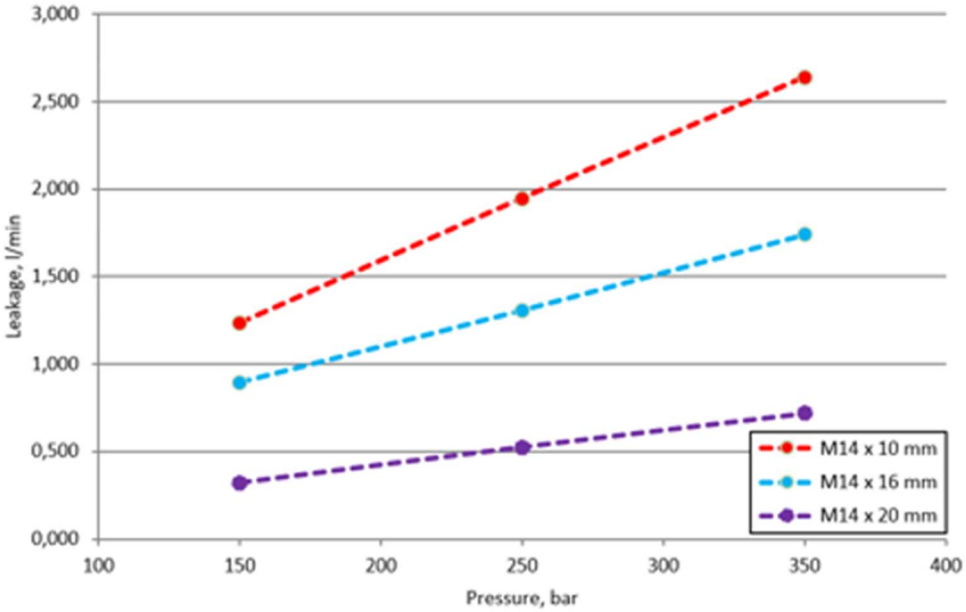


Figure 13. Leakage of control measurements based on thread length [13].

4.2. The main measurement results

During the primary measurements, different parameters influencing the sealing of threaded plugs when using sealing paste were monitored. The initial test series involved an M6 thread with variable thread lengths (10 mm, 16 mm, and 20 mm). The samples were subjected to pressures of 150 bars, 250 bars, and 350 bars, and the leakage was observed. The results showing the influence of thread length on sealing are presented in Table 2.

Table 2. Results of sealing M6 pins according to thread length with sealing paste [13].

Subject number / thread length mm	**Leakage, drops / h**		
	150 bar	250 bar	350 bar
1/10	No leaks	No leaks	No leaks
2/10	No leaks	1,9	8,6
3/10	No leaks	No leaks	3,4
1/16	No leaks	No leaks	No leaks
2/16	No leaks	No leaks	No leaks
3/16	No leaks	No leaks	No leaks
1/20	No leaks	No leaks	No leaks
2/20	No leaks	No leaks	No leaks
3/20	No leaks	No leaks	No leaks

Based on the results from Table 2, we can confirm the hypothesis that thread length has an impact on sealing with sealing paste, meaning that longer thread length results in less leakage. In Table 3, the next series of tests using sealing paste with M10 thread and the influence of pin material are presented. In all measurements, the thread was M10, with the only difference being whether the pin was made of stainless steel or burnished steel.

When examining the effect of pin material on sealing, it can be observed that initially, burnished steel (B) had greater leakage than stainless steel (S). However, towards the end of the tests, stainless steel exhibited higher leakage than burnished steel. It should be noted that in no case did the hydraulic block achieve complete sealing, indicating a potential error in assembly or in the manufacturing of the test specimens. Considering the low probability of an assembly error occurring in all pieces, it is suspected that the hydraulic blocks were fabricated using worn-out tools, resulting in excessive clearance in the threads, which hindered effective sealing.

Based on the results in Table 3, it is not possible to confirm or refute the hypothesis that the material of the pins affects the adhesion of sealing paste and consequently the sealing of the joint.

Table 3. Leakage results of M10 x 10 threaded pin with the use of sealing paste - influence of pin material [13].

Subject number / material type	**Leakage, drops / h**		
	150 bar	250 bar	350 bar
1/S	1,0	3,5	7,7
2/S	1,9	7,4	18,5
3/S	1,5	8,7	17,2
1/B	1,7	5,3	12,3
2/B	5,1	10,1	10,9
3/B	1,5	3,6	5,9

Graphical representation of the results and their comparison is presented in Figure 13.

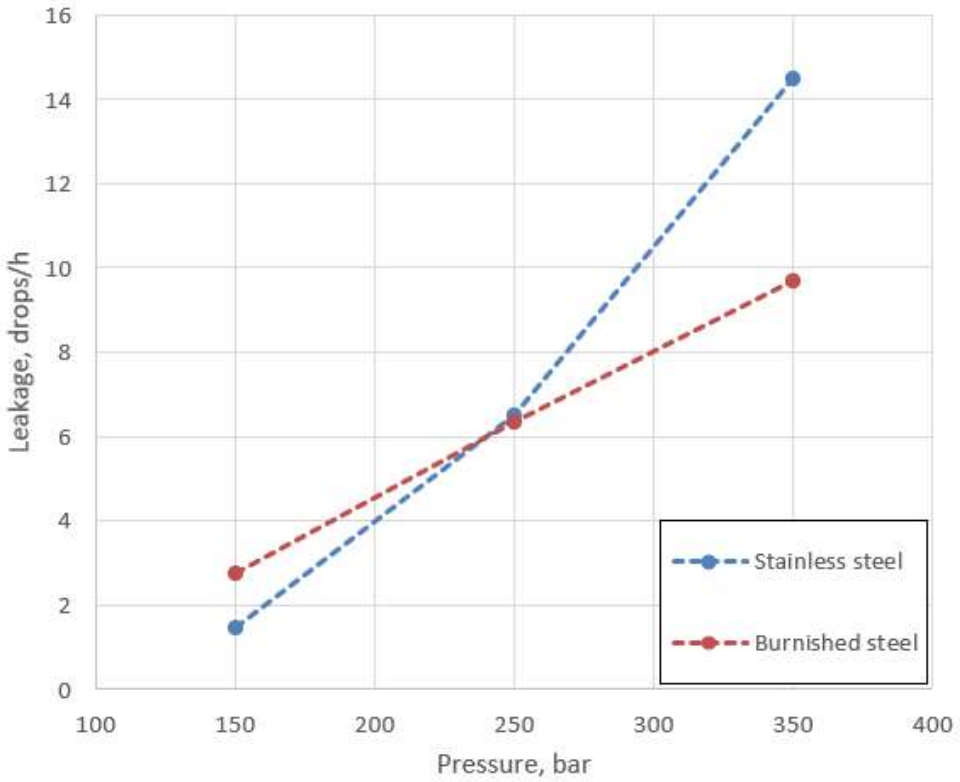


Figure 14. Graphical representation of leakage results - influence of threaded pin material [13].

In the Table 4 the third series of tests without the use of sealing paste on M10 thread and the influence of tightening torque on the sealing of threaded pins are presented. In all measurements, M10 threads with a length of 10 mm were used, where the pin was initially tightened to the hydraulic block with a torque of 5 Nm, and then the torque was increased by an additional 90°, followed by repeated measurements.

Table 4. Leakage results of M10 x 10 threaded pin without the use of sealing paste - influence of torque [13].

Subject number / tightening torque, Nm	**Leakage, l / min**		
	150 bar	250 bar	350 bar
1/5	0,3	0,2	0,4
2/5	0,6	0,9	1,3
3/5	0,6	0,8	0,9
1/5+90°	0,2	0,3	0,5
2/5+90°	0,4	0,6	0,9
3/5+90°	0,5	0,7	0,8

While examining the influence of tightening torque without the use of sealing paste on the sealing efficiency, it is evident that there is a partial reduction in leakage as the tightening torque increases. Consequently, the results from Table 4 confirm the hypothesis that tightening torque affects the sealing of the joint without the use of sealing paste, with higher tightening torque resulting in improved sealing.

The graphical representation of the results is shown in Figure 14.

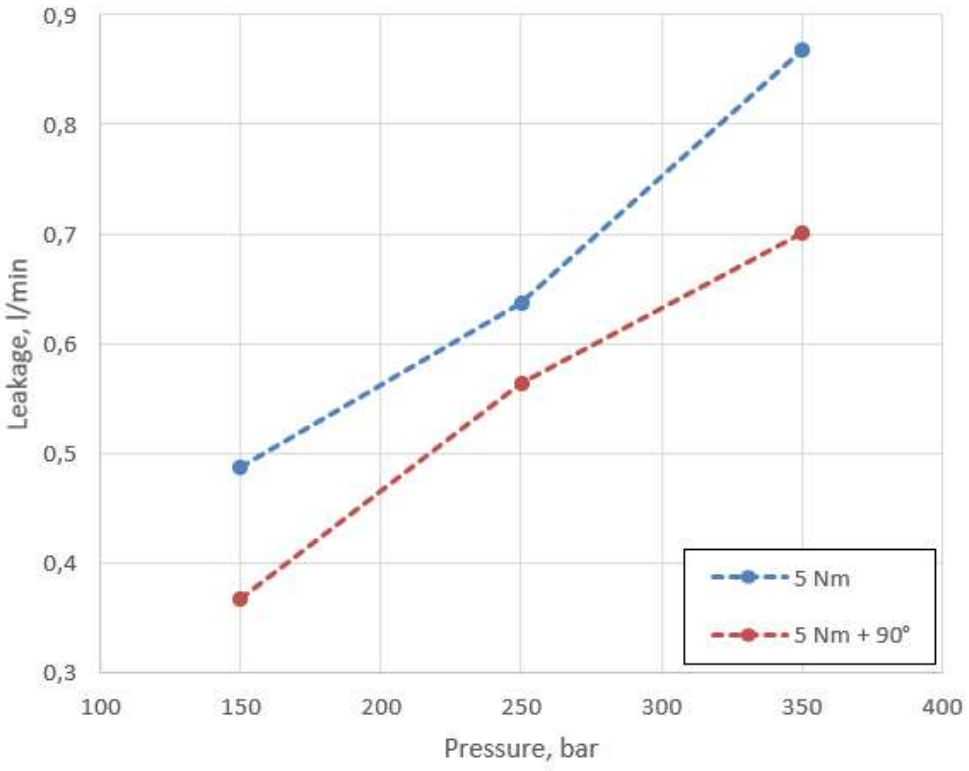


Figure 15. The graphical presentations of the results - influence of torque [13].

Series of tests with the use of sealing paste on M10 threaded inserts with different tightening torques are presented in Table 5. Measurements were conducted at 0 Nm, 40 Nm, and 80 Nm of tightening torque.

During the investigation of the impact of tightening torque in combination with sealing paste on sealing performance, it is evident that leakage reduces as the tightening torque increases. As a result, the hypothesis suggesting that the combination of tightening torque and sealing paste might displace the sealing paste and lead to inferior sealing can be refuted based on the results presented in Table 5.

Table 6 presents the results of the following test series, using sealing paste with different thread diameters while maintaining a constant length of 10 mm. The investigation into the influence of thread diameter on sealing with the use of sealing paste revealed that there is no significant deviation in leakage with increasing thread diameter and, subsequently, an increase in thread clearance due to a larger thread pitch. This holds true as long as the clearance within the thread remains below the maximum clearance of the sealing paste, which, in our case, is 0.25 mm. Consequently, the hypothesis suggesting that thread diameter impacts joint sealing can be refuted.

Table 5. Leakage results of threaded inserts with the use of sealing paste in combination with tightening torque [13].

Subject number / tightening torque Nm	**Leakage, drops / h**		
	150 bar	250 bar	350 bar
1/0	No leaks	No leaks	No leaks
2/0	No leaks	No leaks	1,2
3/0	No leaks	2,5	8,2
1/40	No leaks	No leaks	No leaks
2/40	No leaks	No leaks	No leaks
3/40	No leaks	No leaks	No leaks
1/80	No leaks	No leaks	No leaks
2/80	No leaks	No leaks	No leaks
3/80	No leaks	No leaks	No leaks

Table 6. Leakage results of threaded pin with the use of sealing paste – influence of thread diameter [13].

Subject number / diameter size, mm	**Leakage, drops / h**		
	150 bar	250 bar	350 bar
1/6	No leaks	No leaks	No leaks
2/6	No leaks	1,9	8,6
3/6	No leaks	No leaks	3,4
1/10	1,7	5,3	12,3
2/10	5,1	10,1	10,9
3/10	1,5	3,6	5,9
1/14	No leaks	No leaks	No leaks
2/14	No leaks	No leaks	1,2
3/14	No leaks	2,5	8,2

5. Conclusion

The paper presents a study on the applicability of threaded pins according to SIST ISO 4026 for sealing holes in hydraulic blocks as an alternative to existing solutions. Several tests were conducted within the scope of the research to investigate the influences of various parameters that could affect the quality and reliability of such sealing joints.

The study identifies parameters that contribute to achieving more reliable and effective sealing of the drilled holes. The results of the research indicate that hydraulic blocks can be effectively and reliably sealed using a combination of sealing paste and threaded pins.

Further research can be directed towards exploring the potential influences of materials on sealing effectiveness, as well as conducting experiments involving dynamic loads to assess the impact of material fatigue on sealing paste performance and sealing results.

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Contribution to the analysis of the mechanical characteristics of composite materials in civil engineering

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Abstract. Composite materials are made of two or more different types of materials, each of which has unique properties that, when combined, produce a new material with enhanced physical, chemical, and mechanical properties. Such material is created and applied for a specific purpose. This paper's objective is the analysis of the composite materials used in construction, product development, production, their mechanical characteristics and the use of the specific product. Given that concrete is a composite material that is often used, the application of new reinforcing materials provides a number of advantages such as light weight, flexibility and easier installation, corrosion resistance and durability.

1. Introduction

Composite materials are everywhere around us. Such materials can be found in nature. For example, we can take a piece of wood that is also a composite. It consists of long cellulose fibers held together. Another example would be concrete and concrete structures that are also a composite. Taking into account the above, we can conclude that composite materials consist of two or more materials of different characteristics and properties, with the fact that they do not merge or dissolve into each other. The combination of materials in this way aims to create a new material with significantly improved characteristics compared to the materials we have been using. These characteristics can be reflected in better temperature stability, less weight, tensile strength, bending strength, etc.

The application of composite materials dates back to 4000 BC. where laminated writing material from the papyrus plant was used. Papyrus was the first writing material and took on many of the properties of what we know today as paper. 1300 BC The Egyptians and Mesopotamians used straw and mud to make bricks that would later be used to build houses. The process of making these bricks is adding straw to the mud and forming an oblong shape of bricks using various molds. This made building houses much easier. In this way, the houses would stay cool in hot weather and warm in winter days. In 1200 AD the Mongols invented the composite bow. The bow consisted of a combination of animal glues, bone, and wood.

If one were to take into account the simultaneous origin and use of composite materials, the importance of such materials can be clearly concluded. Today, composite materials are used in almost every field of science and research. Thus, today these materials have found their use in the automotive industry, rocket industry, aviation, medicine, weapons production, construction, etc. Today, the industry for the production of composite materials is still developing. Composites are created that are used exclusively for what they will be used for. This chapter will attempt to describe the composite materials used in construction in terms of their mechanical properties, production, uses, advantages and disadvantages.

2. Composite materials

2.1. Definition of composite materials

Composite materials are obtained by combining two or more different materials in order to obtain a new material with improved characteristics compared to the combined materials. In principle, composite materials consist of a basic material, which we call a matrix, and an additional ingredient that acts as a filler or reinforcement. The purpose of such materials is to prevent the two materials from fusing and dissolving into each other [1].

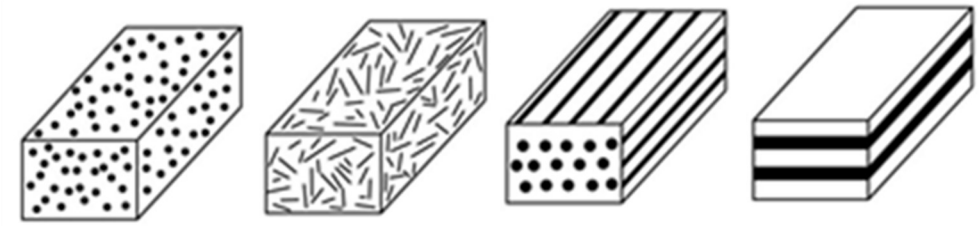

Figure 1. Basic types of composite materials: a) particles, b) fibers, c) continues fibers, d) sheet laminates.

By combining two or more different materials in this way, unusual combinations of material characteristics such as strength, rigidity, temperature stability, chemical stability, thermal or electrical conductivity, etc. can be achieved.

2.2. Division of composites

As technology and technique advance more and more rapidly, new types of composite materials appear as well. The general division of composites, considering the matrix, can be classified into three groups:

- Metal composites.
- Ceramic composites.
- Polymer composites.

Composites can be further divided according to:

- Matrix material (metal composites, polymer composites, ceramic composites).
- Material reinforcement (composites with fiberglass or with metal reinforcement).
- Form of reinforcement (fibrous composites, composites with particles).
- Arrangement of reinforcements (continuous composites, discontinuous composites).
- Manufacturing process (directly pressed composites, rolled composites).
- Application (construction composites, electrotechnical composites).

All combinations of the above groups of composites are possible, such as:

- Metal-metal.
- Metal-ceramic.
- Metal-polymer.
- Ceramic-polymer.
- Ceramic- ceramic.
- Polymer-polymer.
- Polymer-metal.

Composites can further be reinforced with fibers, particles, structural composites and cellular rigid bodies.

2.3. Metal composites

Composites with a metal matrix are very interesting and widely used because they are able to provide a higher operating temperature than base metals, but they can also be shaped so that greater strength, better thermal conductivity, stiffness, abrasion resistance, creep resistance and dimensional stability can be obtained. In metal matrix composites, the continuous or matrix phase is generally an alloy, less often a pure metal, and the reinforcement consists of high-value carbon, metal, or ceramic additives [1].

The most prominent characteristics of metal matrices are visible in distinct forms, especially in that the metal matrix gives a metallic nature to the composite in terms of thermal and electrical conductivity, production processes and interaction with the environment. The dominant mechanical properties of the matrix, such as modulus of elasticity and transverse strength of directional-reinforced composites, are sufficiently high in some metal-matrix composites that unidirectional stacking is possible in some engineering structures [1].

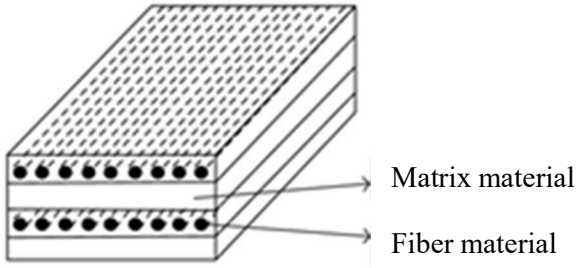

Figure 2. Method of obtaining composite materials.

Composites with a metal matrix can be divided into:

- Composites with an aluminum matrix.
- Composites with magnesium matrix.
- Composites with a titanium matrix.
- Composites with a copper matrix.
- Composites with a superalloy matrix.

2.4. Ceramic composites

Ceramic composite materials are materials consisting of a ceramic matrix in which there are fibers, particles or tiles of other materials to improve mechanical properties. These materials combine the advantages of ceramics, such as high hardness, resistance to high temperatures and chemically aggressive media, with the advantages of other materials, such as high strength and durability [3].

Ceramic composites are used in various industrial sectors such as aerospace, automotive, medical and energy industries. Applications include the manufacture of engines, turbine blade components, brake systems, bone implants, insulating materials, etc.

Figure 3. Composites in the automotive industry.

Figure 3. shows an example of the use of ceramic composite materials in the automotive industry. Some examples of ceramic composites are:

- Carbide reinforced ceramic composites.
- Oxide-strengthened ceramic composites.
- Whisker reinforced ceramic composites.

As already emphasized, the advantages of ceramic composites include high strength, hardness, high temperature resistance, chemical inertness, and low density. However, they also have some challenges such as a tendency to break on impacts and a complex manufacturing process which makes them more expensive. Nevertheless, due to their unique properties, ceramic composites are increasingly being used in industry as a substitute for traditional metals and plastics in many applications.

Ceramic composites are used in a variety of industries, including aerospace, automotive, energy, medical, and many others [3]. Applications include making engines, components for turbine blades, brake systems, bone implants, insulation materials, etc.

Technology and research related to ceramic composites is constantly developing, so more advanced materials and applications can be expected in the future.

2.5. Polymer composite materials

Polymer composites are materials consisting of polymer matrices. Other materials, such as fibres, particles or flakes, are embedded in this matrix. These composites combine polymer characteristics such as light weight, flexibility and corrosion resistance, with improved mechanical properties due to the inserted materials [4]. There is a wide variety of polymer composites, some of which include:

- Reinforced polymer composites. In these composites, fibers or particles are incorporated into the polymer matrix to improve strength, stiffness and stress resistance. Fibers can be made of glass, carbon or aramid materials, and polymers are often used, such as epoxy, polyester or polyamide.
- Composites with filling. These composites consist of a polymer matrix in which fillers, such as particles, flakes or powder, are embedded. These fillers can significantly improve the mechanical properties of composites such as hardness, stiffness, wear resistance or thermal properties. Examples include filling polymers with fiberglass, ceramic particles, or metal fillers.
- Polymer composites with structural foams. These composites include a polymer matrix into which structural foams are embedded. These foams can be open (porous) or closed (with gases trapped within the structure).

Polymer composites have many applications in various industries. Some examples include:

- Aviation and space industry.
- Automotive industry.
- Construction industry.
- Sports industry.
- Medical industry.

Polymer composites continue to be developed and innovated in order to improve their performance, reduce manufacturing costs and expand the possibilities of application in various industries.

3. Mechanical characteristics of composite materials in construction

3.1. Composite materials in construction

Composite materials in construction have several mechanical characteristics that make them attractive for use in various construction applications. Some of the most important mechanical properties of composite materials in construction include:

- High strength to weight ratio.

- High tensile strength.
- Good corrosion resistance.
- High impact resistance.
- Good insulation.

The mechanical characteristics of composite materials can vary depending on the type of polymer, reinforcement and method of production. The specific performance of composites can be adjusted for specific construction requirements, namely:

- High tensile strength.
- High compressive strength.
- High bending strength.

Composite materials have high bending strength, which makes them suitable for use in various structural elements. This characteristic enables composites to provide the necessary support and durability in structures such as girders, bridges or slabs.

3.2. Application of composite materials in construction

Composite materials are widely used in construction due to their exceptional properties such as high strength, low mass, corrosion resistance, flexibility, insulation and many other characteristics. Although we are not aware of it, composite materials surround us greatly with their application. Therefore, reinforced concrete is one of the most commonly used composite materials in construction. It consists of concrete as a matrix and steel reinforcing bars that give it reinforcement and stress resistance. It is used for the construction of foundations, columns, beams, slabs and other structures. In many buildings, we can replace these steel reinforcing bars or reinforcements with bars made of composite materials. The most commonly used materials for the production of such composites are fiberglass, carbon fibers, aramid composites (eg Kevlar) and composites with natural fibers.

The most commonly used composite materials in construction applications are:

- Reinforcements and rebars where composite materials, such as fiberglass (GRP) or carbon fiber (CFRP), are used to strengthen concrete structures, bridges, columns, walls and other structures. They can improve strength, durability and stress resistance.

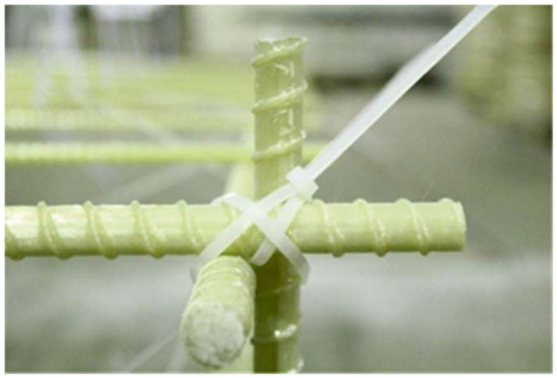

Figure 4. Reinforcement made using composite materials in construction.

- Panels for walls and roofs.
- Pipes and containers.
- Facade coverings.
- Floors.
- Construction grids, nets, bars and supports.

3.3. Advantages of composite materials in construction

Composite materials have many advantages in the construction industry, which explains their increasing use. Some of the advantages of composite materials in construction are:

- High tensile strength especially for those with reinforced fibers such as fiberglass, carbon fibers or aramid fibers.
- High compressive strength (columns, beams or panels).
- High bending strength (girders, bridges or plates).
- Light weight.
- Corrosion resistance.
- Environmental sustainability.

3.4. Disadvantages of composite materials in construction

Although composite materials have many advantages in the construction industry, they also have some disadvantages. Some of the key disadvantages of composite materials in construction are:

- High price.
- Impact sensitivity and damage.
- Fire and heat.
- Maintenance and repair.
- Recycling and sustainability.

All these disadvantages must be taken into account when considering the application of composite materials in construction. Each project should be evaluated in detail, specific requirements should be considered taking into account costs, safety, sustainability and practicality of composite materials in that context.

3.5. Fiberglass

Fiberglass is one of the most commonly used reinforcing materials in composite materials when used in construction. It is made with thin fibers that are made of glass, often in the form of long bundles or fabrics. These fibers are used to increase the strength and durability of composite materials. These include high tensile strength, exceptional impact strength, corrosion resistance, low cost, and relatively simple processing. Fiberglass have a relatively low density, which means that adding these fibers to the composite material does not significantly increase the weight of the structure. This is especially important in construction applications where you want to achieve greater strength, but at the same time reduce the total mass of the structure.

Figure 5. Fiberglass pieces.

Figure 5 shows fiberglass pieces. It is most often used as additional reinforcement in concrete structures.

Figure 6. Coiled fiberglass.

This type of fiber is used to reinforce polymer matrices, such as epoxy or polyester, in order to improve the mechanical characteristics of the composite. Fiberglass are usually added to the matrix in the form of bundles or fabrics. During the curing of the matrix, the fiberglass become firmly connected to the matrix. The fibers absorb most of the stress that occurs in the material and distribute it throughout the composite, which leads to increased strength, stiffness and resistance to cracking of the composite material.

It is very important to consider that the use of fiberglass in composite materials also has some limitations. For example, fiberglass are relatively fragile and can be easily damaged by impact or bending. Also, it is possible for the fibers to become visible on the surface of the material if they are improperly arranged or if there is uneven matrix application.

3.6. Carbon fibers

Carbon fibers are another type of reinforcing material that is often used in composite materials in construction. Carbon fibers are obtained by pyrolysis of organic materials, such as polyacrylonitrile fibers, at high temperatures in a controlled atmosphere and without the presence of oxygen. These fibers are extremely strong, light and have high strength in relation to their weight. The key features that would make us choose to use carbon fiber in composite materials would be the exceptional strength and compressive strength in the first place. They are much stronger than steel, but significantly lighter.

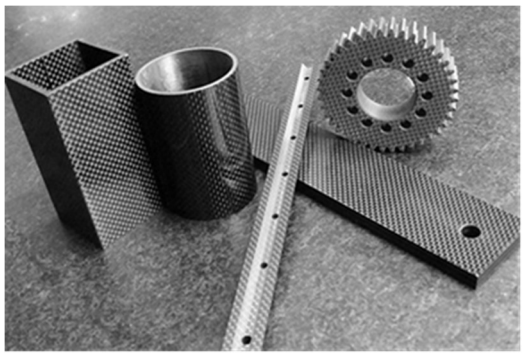

Figure 7. Carbon fiber examples.

Low mass is another great advantage of carbon fiber. Carbon fibers have a very low density, which means that adding these fibers to a composite material will not significantly increase the overall mass of the structure. This is especially important in construction applications where high strength is required while reducing weight. In addition to all the above mentioned advantages, carbon fibers have very high stiffness and bending strength, high temperature resistance and corrosion resistance.

These fibers have many advantages in composite materials, but there are also some limitations. For example, carbon fiber is brittle in the sense that it can break easily under impact, so more care is needed in handling and processing. Also, the cost of carbon fibers can be relatively high compared to

other materials, which can limit their wider application. In any case, carbon fiber is a very important component of composite materials in construction because of its high strength, low mass and resistance to corrosion.

3.7. Armide fibers

Armid fibers, also known as Kevlar, are high-strength synthetic fibers that are often used as reinforcement in composite materials. Armide fibers are made of polyamide or polyamide polymer.

Characteristic properties of aramid fibers are exceptional strength, resistance to tearing and high modulus of elasticity. They are significantly stronger than steel, but have a much lower density, which makes them an extremely light material. Armide fibers are five times stronger than steel, but have only about a third of its mass.

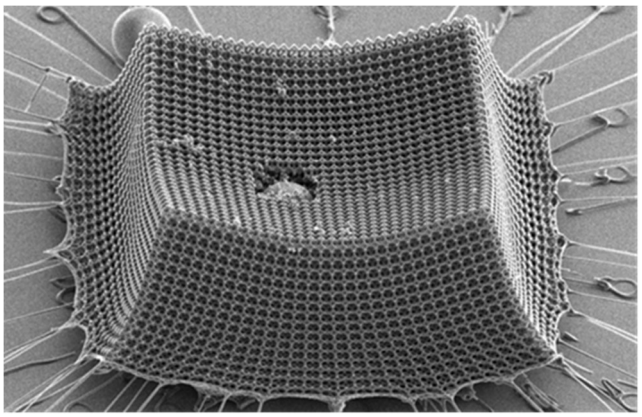

Figure 8. Bulletproof aramid fiber, better known as Kevlar.

In composite materials, aramid fibers are usually combined with a resin (polymer) to form a matrix. The matrix holds the aramid fibers together and transfers stresses to the fibers. Armide fibers are often used in construction applications where high strength and durability are required. This may include structures such as bridges, impact protection structures (eg reinforced concrete walls), blast resistant panels, reinforced concrete or protective equipment such as helmets, body armor and protective clothing.

3.8. Thermoplastics

Thermoplastics are one of the main categories of polymers used in construction and other industries. They are thermoplastic materials, which means they can be softened and reshaped by heat. This makes them very flexible and adaptable materials for various construction applications.

Figure 9. Example of drainage pipes made of composite materials.

Thermoplastics have high impact resistance, which makes them suitable for use in building structures, pipes, electrical equipment housings and other parts that may be exposed to physical

damage. Many thermoplastics have high dielectric strength and good electrical insulating properties. This makes them suitable for use in electrical installations, insulating materials and electronic components.

Applications of thermoplastics in construction are diverse. Some examples include:

- Pipes and sewage systems.
- Insulating materials.
- Windows and doors.
- Coatings and membranes.
- Coverings and panels.

The selection of the appropriate thermoplastic depends on the project requirements, as well as environmental conditions and exploitation.

3.9. Examination of the mechanical characteristics of composite materials in construction

The testing of composite materials in construction aims to assess their mechanical properties, reliability and ability to withstand the loads they are exposed to in building structures. These tests are performed to ensure the safety, reliability and durability of composite materials in construction applications. Some of the most common tests applied to composite materials in construction include:

- Mechanical strength tests.
- Adhesion test.
- Abrasion resistance test.
- Examination of dimensional stability.
- Fire resistance test.
- Durability test.

It is most important that tests of composite materials are conducted in accordance with relevant standards and regulations to ensure reliability and compliance with building codes and regulations.

4. Production of composite materials in the construction industry

4.1. Methods of obtaining composite materials in construction

Obtaining composite materials in construction involves combining different components to create a homogeneous material with improved properties. Depending on what material we use, there are several ways in which we can obtain composite materials.

4.1.1. Manual lamination. Manual lamination is one of the procedures for obtaining composite materials that is often used in construction. This process involves manually laying fibers (such as fiberglass, carbon fiber, or aramid fiber) into a mold, then applying a matrix compound (such as polyester resins, epoxy resins, or other polymers) using a brush or roller [7].

Figure 10. An example of manual lamination (hand lamination), application of the mixture with a roller.

Manual lamination allows flexibility and adaptability in the manufacture of composite parts, but requires skill and experience to achieve a quality result [7].

4.1.2. Pultrusion. Pultrusion is a process in which fibers are continuously pulled through a dome containing a liquid matrix (most often a polymer). The fibers and matrix are then passed through a mold and exposed to heat to harden the matrix. This process results in continuously formed composite profiles of fixed length [8].

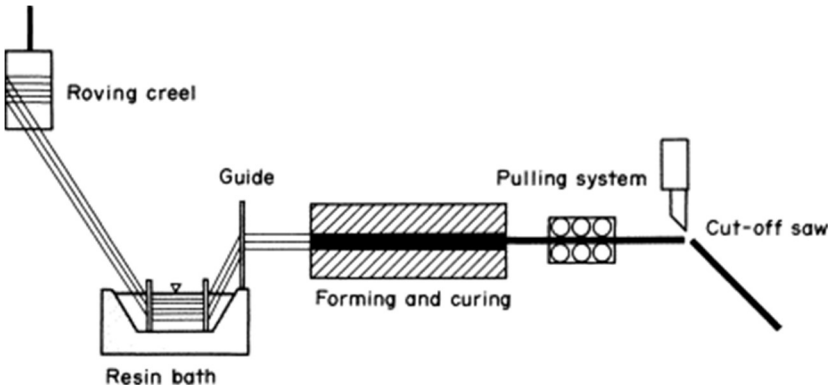

Figure 11. Production of products with constant cross section - pultruding [8].

Figure 11 shows an example of making a product using the specified process with a constant cross section. Pultrusion is often used in the construction industry for the production of various parts and components such as profiled bars, pipes, plates, panels, supports, columns, bridges, stairs and other structural elements [8].

4.1.3. Matrix casting. Matrix casting is a composite material production technique, in which a liquid matrix (polymer) is poured into a mold together with reinforcing fibers to form the desired product shape. This technique enables the creation of complex geometries with high precision and repeatability [1].

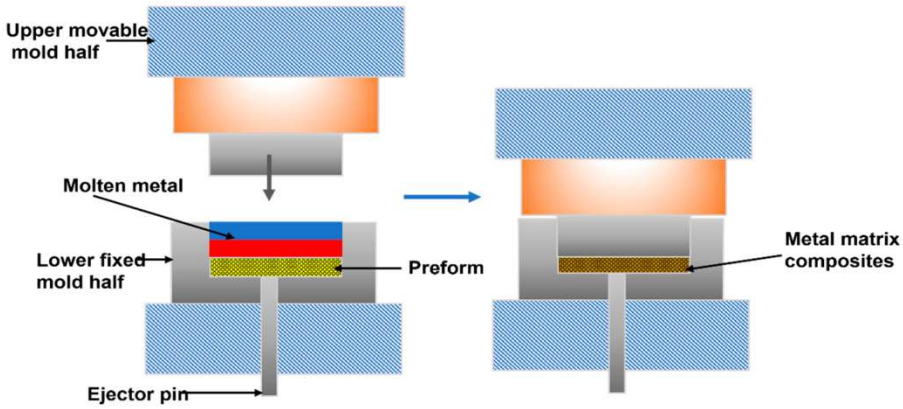

Figure 12. Schematic of production of electronic element by pressureless infiltration using mold, alloy and filler [1].

Reinforcements such as fiberglass, carbon fibers or aramid fibers are prepared in the appropriate form, as strands or fabrics. The fibers can be placed inside the mold in a way that will provide optimal product reinforcement.

4.1.4. Injection molding. Inertial molding is a technique of molding and forming composite materials that uses kinetic energy or inertia to shape the material. In this process, kinetic energy is transferred to the material through impact or a large change in velocity, thereby shaping and compressing the material [6].

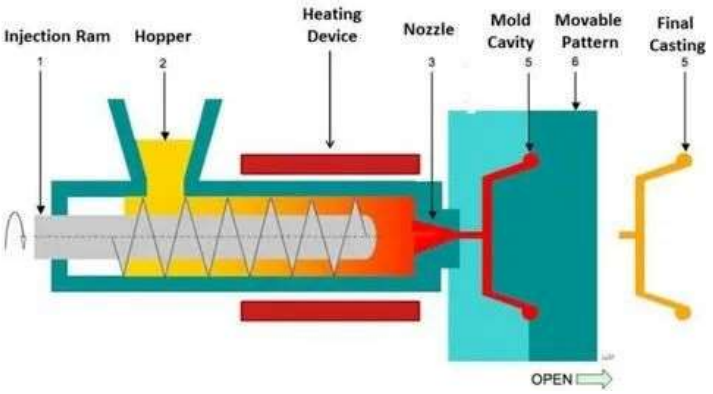

Figure 13. Production of composite materials by injection molding [6].

Inertia pressing enables rapid shaping of materials, which can result in high productivity and reduced production time. This technique enables achieving high precision and repeatability in shaping materials, which is important for achieving consistent results. This technique can be applied to various materials, including metals, polymers and composite materials, and is used in various industries such as automotive, energy, electronics and other sectors where shaped materials with high precision and resistance are required.

4.1.5. Vacuum injection molding. Vacuum infusion casting is a technique used in the production of composite materials. This technique enables the resin to be evenly distributed through the fibrous material using vacuum power, which results in a solid and high-quality composite product [6].

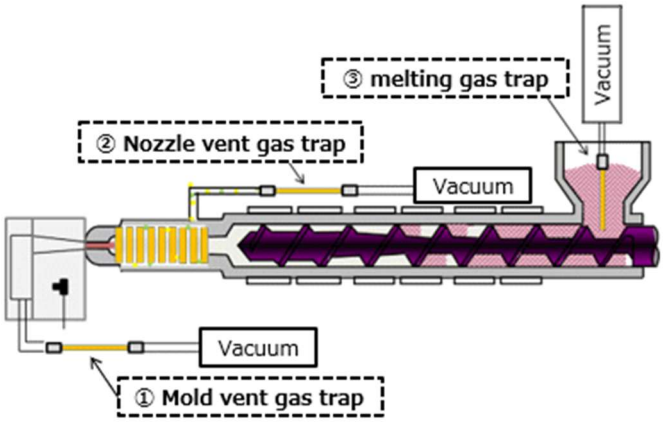

Figure 14. Production of composite materials by injection molding[9].

Fibrous material (fiberglass, carbon fibers, aramid fibers, etc.) is placed inside the mold according to the desired arrangement. This step ensures proper reinforcement of the product. After the mold is completely filled with resin, the resin hardens and the product becomes solid. After curing, the product is removed from the mold and subjected to finishing operations, such as cutting, grinding, polishing, etc., to achieve the final shape and surface finish [6].

4.1.6. 3D print. Advances in 3D printing technology enable the production of composite materials layer by layer. This process uses specialized 3D printers that use fibers and a matrix to print the desired structure layer by layer.

4.2. Matrix material in polymer composite materials

As a rule, the matrix material must fulfill several functions, some of which are crucial for achieving satisfactory system performance [8]. Some of the matrix functions are:

- Fibers and transfers the load to them, and ensures the shape and rigidity of the structure itself.
- Isolates individual fibers that cannot be loaded independently, thus slowing down the spread of the crack.
- Ensures a good surface quality, thus encouraging the production of parts in the final form or close to the final form.
- Ensures protection of reinforcing fibers from chemical influences and mechanical damage.
- With its ductility, the polymer matrix (plastomers) increases the toughness of the composite.
- Due to its properties and compatibility with fibers, it largely affects the type of damage.

4.2.1. Resins in Composite Materials in Construction. When the term "resin" is used in the context of composite materials, one is usually referring to the so-called polymer resin or polymer. Polymer composites are materials that consist of two main components: a polymer binder and reinforcing fibers [6]. A polymer resin can be natural, such as resin obtained from trees, or synthetic, produced under laboratory conditions. Polymer resin is an important component in composite materials as it provides a binding matrix that holds the reinforcing fibers in place and transfers the load between the fibers. Reinforcing fibers, such as fiberglass, carbon fibers or aramid fibers, provide the strength and stiffness of the composite material. Resin is used to bond these fibers into a strong structure and ensure they transfer the load evenly. Resin composite materials are often used in numerous industries, including aerospace, automotive, construction, sports, and many others. They are known for their high strength-to-weight ratio, corrosion resistance, and ability to adapt to different designs.

It is important to note that the field of composite materials is very broad and that there are different types of resins and combinations of resin and reinforcing fibers used for different purposes.

4.2.2. Resin temperature in composite materials. The resin temperature in composite materials in construction can vary significantly depending on the type of resin and the purpose of the material. Commonly used resins in building composites are epoxy resins, polyester resins and vinyl ester resins. Each of these resins has its own specific temperature characteristics:

- Epoxy resins can usually handle operating temperatures of around 80°C to 120°C, although some specialized epoxy systems can handle higher temperatures [5].
- Polyester resins can usually handle operating temperatures of around 50°C to 80°C.
- Vinylester resins can usually handle operating temperatures of around 70°C to 100°C, although some specialized epoxy systems can handle higher temperatures [5].

In specific construction applications, such as panels, laminated elements, linings or reinforcements, the temperature of the resin should be in accordance with the environment and the expected temperature to which the material will be exposed [5].

5. Conclusion

In the comparison and analysis of traditional and composite materials, an evident difference can be observed when it comes to mechanical characteristics and the scope of application of these materials in construction. These characteristics are primarily related to better mechanical and other characteristics compared to traditional materials. By using composite materials, we achieve a number of advantages such as light weight, ease of manufacture, strength, ease of installation, production of more complex parts, better workability and use of materials, and other advantages such as chemical stability, temperature resistance, etc., while on the other hand we consume less energy and time for the development and production of the material itself, all of which is related to the reduction of the total costs required for the production of one such material.

When it comes to composite materials in construction, they are used in almost all branches of the construction industry. A new composite material is being developed every day, and this enables

combining several different materials. Composite materials in construction have a number of disadvantages, however, in any case, these disadvantages are negligible compared to what we get from their use. Before using composite materials in construction, it is important to know in advance the purpose of the specific product so that the combination of materials can be best adapted to the required mechanical and other characteristics.

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Application of the program package SOLIDWORKS2020 in the construction of machine elements

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Abstract: In the modern industry, there is a great need for simpler and more practical CAD software packages intended for 3D modelling. From the student experience, the integrated 3D product development system SolidWorks stands out as the most practical. Its application is very widespread because it enables easy and efficient shaping and designing of products, enabling a quick transition from 2D to 3D model, connection of elements, i.e. assembly into a finished product and creation of associated workshop drawings ready for the further process of production preparation. When assembling different assemblies, it is possible to use standard elements from the Toolbox within the Design Library. In addition, if it is about dynamic assembly, there is a possibility of displaying, i.e. making an animation of its work. The connection between drawings and reality is reflected in the option of testing stress loads and weaknesses using in-program analysis such as the finite element method. The aim of this paper isto describe the procedure of using SolidWorks when constructing a specific machine element.

1. Introduction

SolidWorks is a computer-aided design (CAD) and engineering (CAE) software solution for solid modeling founded in December 1993 by MIT graduate Jon Hirschtick. Hirschtick organized a team of engineers with the goal of creating 3D CAD software that was accessible, affordable and available for the Windows desktop. In 1995, SolidWorks released its first product: SolidWorks 95. Since 1997, SolidWorks is owned by the French company Dassault Systèmes, best known for its CATIA software. [1]

2. Reducers

Given that SolidWorks is one of the strongest tools with a really large application in mechanical engineering and engineering in general, the features and mentioned possibilities of this program package are explained using the example of a reducer.

A reducer (lat. *redactor*) is a mechanical transmission that reduces the rotation's speed of the drive shaft, working spindle and other elements and at the same time the rotation's speed of the driving machine or vehicle is being adapted to working conditions. The transmission of power and movement in a reducer is performed by the special shape of its parts (for example, gears) or by friction (for example, a belt). [2] Graphic example of a gear reducer is shown in figure 1.

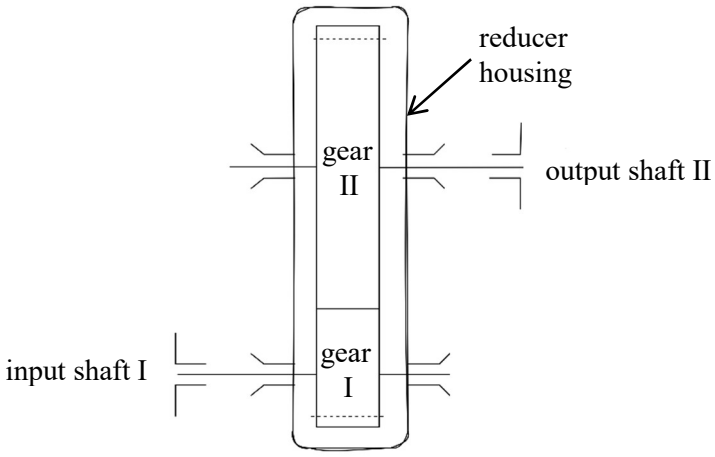

Figure 1. Graphic example of the gear reducer.

The example of a reducer in this paper essentially represents an assembly that is consisted of one pair of gears in the required mutual relationship, while the power, i.e. the number of revolutions, is brought to the smaller gear via the so-called input shaft. Given that the power is transferred from a smaller gear to a larger one, the necessary reduction in the number of revolutions occurs, which is the main task of the reducer, which is further taken to the required places by the output shaft. At the same time, a transmission ratio is bigger than one.

2.1. Division of reducers

Reducers can be divided in different ways, according to the:

- type of reducer,
- position of the input and output shafts and
- number of gears.

According to the type, reducers are divided into reducers with parallel shafts, with shafts that intersect and with shafts that crosses each other. A separate group includes planetary reducers and the so-called motor-reducers. [3]

According to the position of the input and output shafts, reducers with parallel shafts are divided into reducers with shafts in a horizontal plane, shafts in a vertical plane and in some inclined plane. In reducers with intersecting shafts, the input shaft is usually in the horizontal plane, while the output shaft can be in the horizontal or vertical plane. In gearboxes with intersecting shafts, the input shaft of the worm screw can be below, above or to the side of the worm gear. In the first two cases the worm gear shaft lies in the horizontal plane, and in the third it lies in the vertical plane. Reducers with parallel shafts can have an input and output shaft with one or two inputs and outputs. The input shaft of the reducer with intersecting or crossing shafts has only one input, and the output has one or two outputs. [3]

According to the number of gears, reducers can be single-stage or multi-stage. The difference is only in the number of cylindrical gears with parallel shafts. Single-stage has one pair, but multi-stage has two or more pairs.

Two-stage reducer is shown in the following figure.

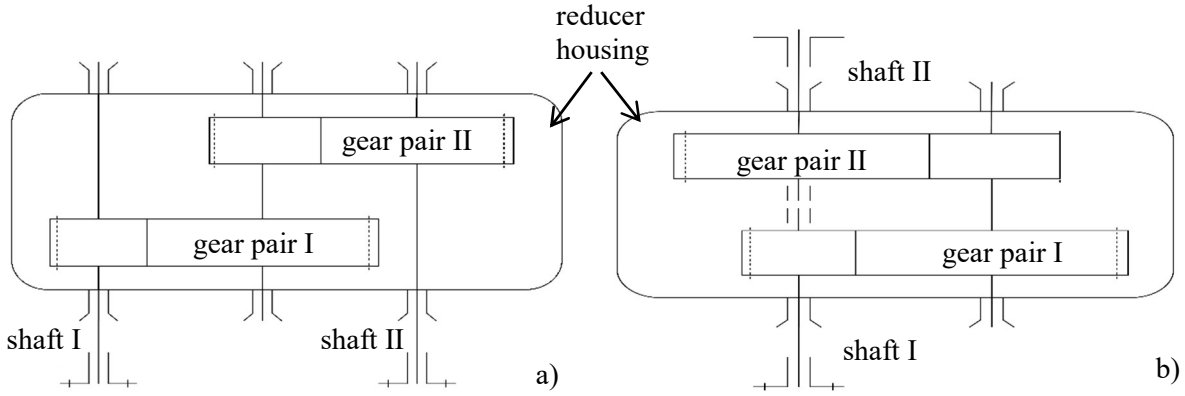

Figure 2. Two-stage reducer with:
a) stretched construction, b) coaxial construction.

The mentioned types of reducers refer to reducers with a constant transmission ratio, which is the subject of this paper. However, in addition to these, there are also reducers with a variable transmission ratio, the so-called changers.

3. Modeling example of reducer

Modeling is the process of creating 3D models, that is, arranging geometric bodies so that they look like objects, spaces or characters [4]. Since the reducer is a relatively complex assembly, it is necessary to model all its components: input and output shaft, gears, bearings, bearing caps, upper and lower housing, standard elements such as bolts and nuts. The mentioned elements were created in SolidWorks and are shown in the rest of the work.

3.1. Shaft modeling

The drive shaft is modeled together with the drive gear, which is also directly extracted from the Toolbox. The input data for it was obtained from the calculation. The driven shaft is modeled according to the dimensions of the output gear and the specific spline.

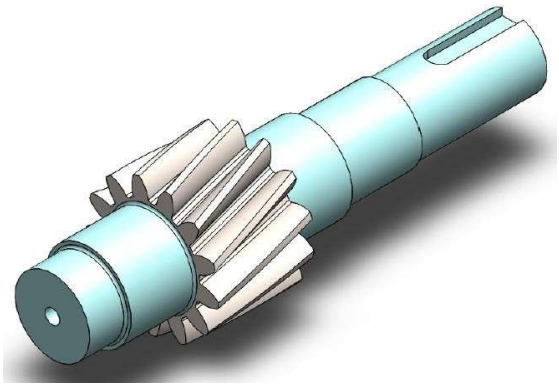

Figure 3. Toothed drive shaft.

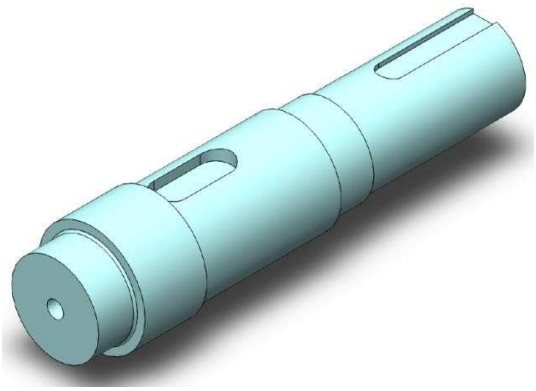

Figure 4. Output/driven shaft.

3.2. Gear modeling

Gear modeling begins with the calculation of the essential elements of the gear, such as the module, diameters, center distance, and the like. SolidWorks offers the possibility to directly extract the finished gear model from its Toolbox, with the fact that desired data has to be entered.

Such a way of modeling gears is shown in the following figure.

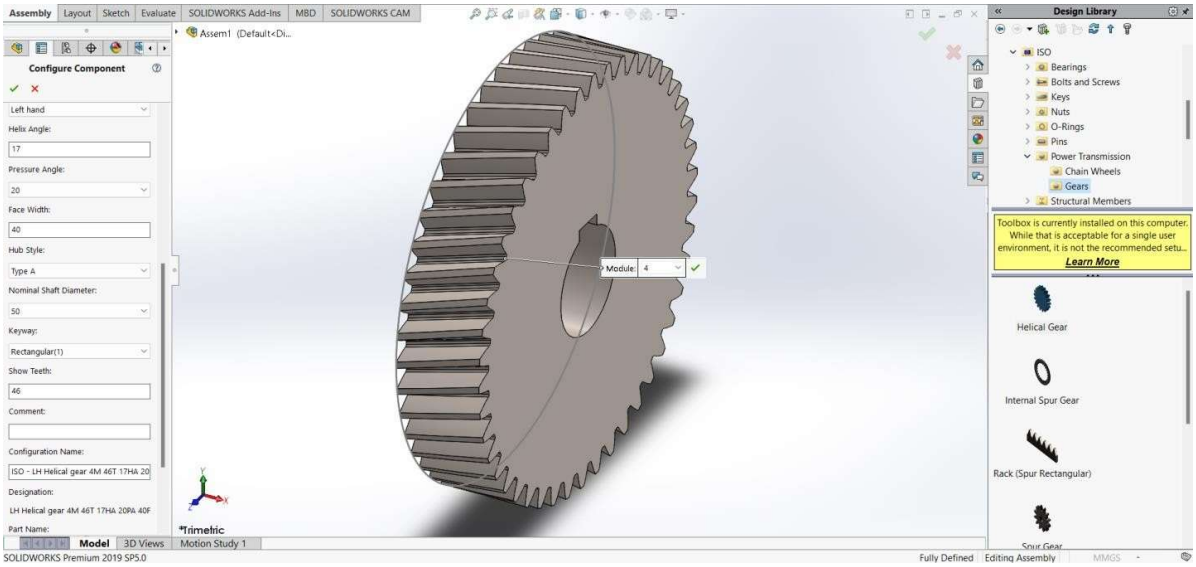

Figure 5. Gear modeling.

This way of adapting an already existing gear model greatly speeds up the modeling process.

3.3. Modeling of the reducer housing

When modeling the lower part of the housing, it is necessary to take into account the distance between the axles, the length of the shafts and the places where the bearings come. Both parts of the case are shown in the following figures.

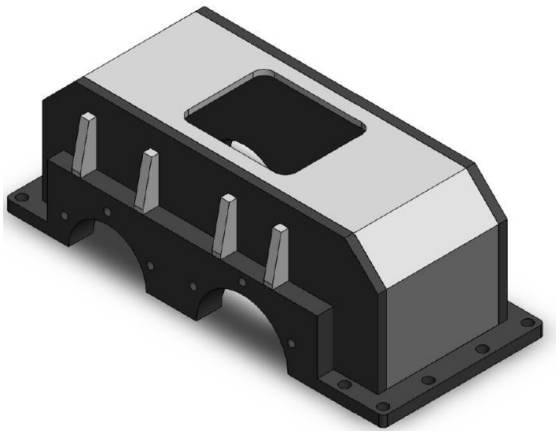

Figure 6. The upper part of the case.

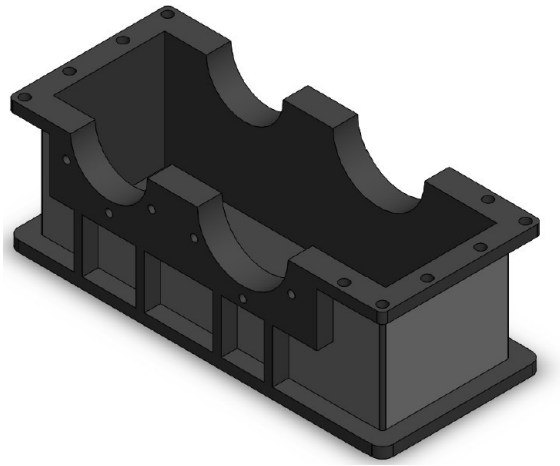

Figure 7. The lower part of the case.

The difference between the upper and lower parts of the case is only in the slope of the two edges on the upper case. The reason for this is the reduced size of the entire reducer [5].

3.4. Bearing modeling

The bearing is obtained by selecting a finished radial bearing model from the Toolbox and the corresponding standard (Figure 8), while its cover is drawn according to dimensions.

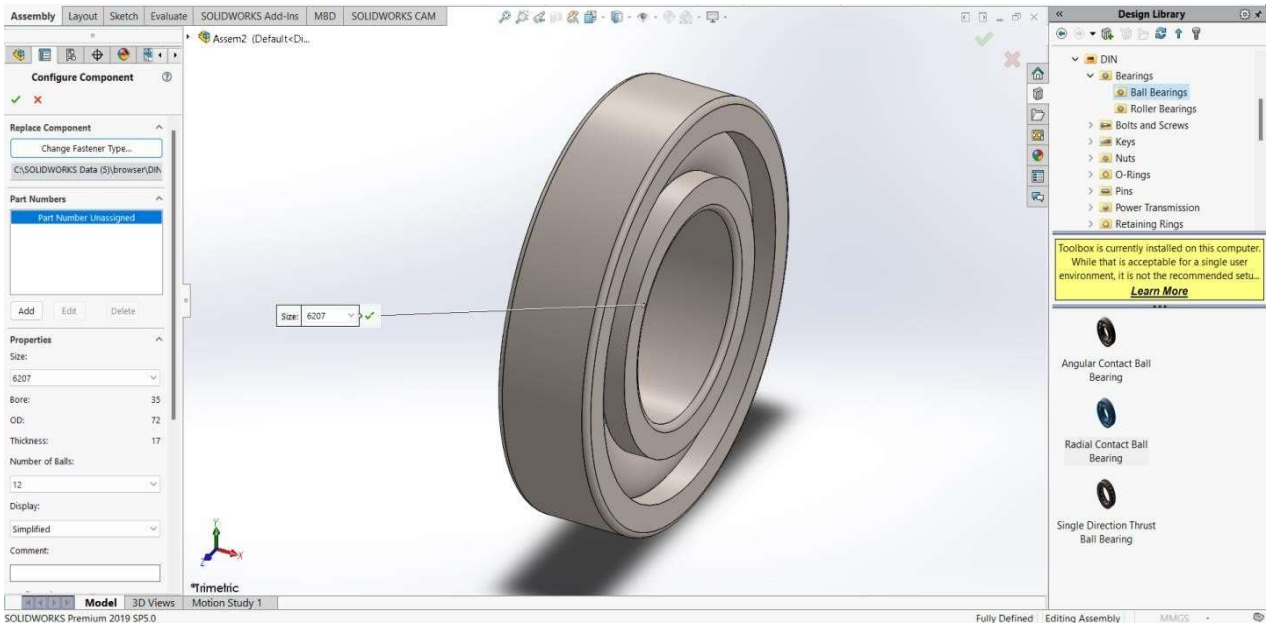

Figure 8. Bearing modeling.

The cover is located on the surface of the housing and protects against axial movement and at the same time prevents the penetration of impurities into the bearing. The creation of the 3D model is shown in the figure.

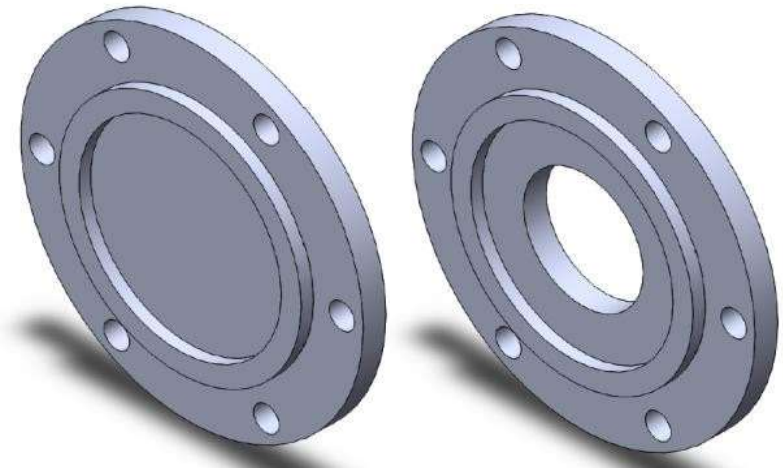

Figure 9. Bearing covers.

3.5. Assembly of reducer elements

The following figure shows all the parts of the reducer. The assembly procedure is explained after that.

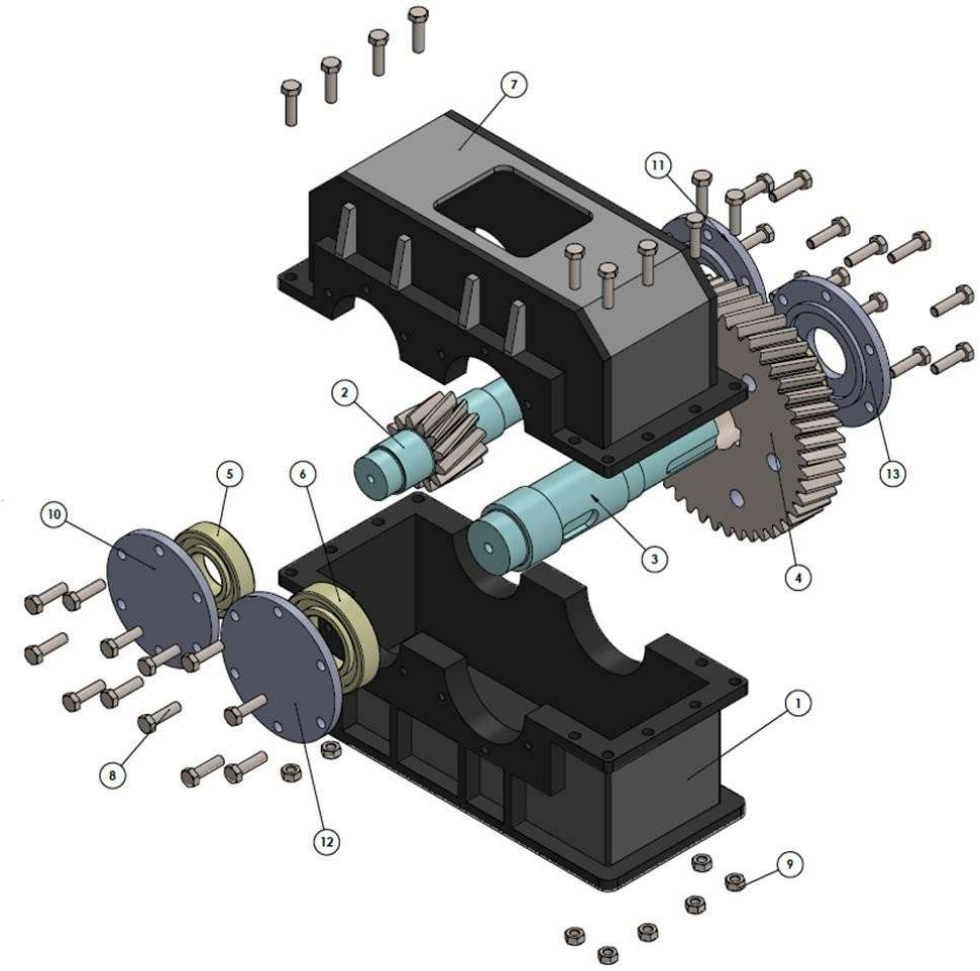

Figure 10. Gearbox assembly.

All lengths and diameters have already been previously defined during the calculation and modeling of individual reducer elements. The assembly schedule can be arbitrary and in several ways. One way is to put gears (4) on the shaft (3) that transmit the torque, with the fact that the drive shaft (2) is already made together with the gear. It is followed by bearings (5,6) which are placed on the surface of the shaft. Everything connected in the first part is inserted and connected to the lower case (1). The bearings are placed in such a way that they sit on the housing that will be processed on that part. The upper part of the housing (7) is placed after the lower part of the housing is assembled with other elements. The surface geometry of the upper and lower casing should be defined in such a way that it would not leak oil during operation. The holes of the upper and lower parts should be in symmetry to be able to connect with a screw connection. Covers (10,11,12,13) that cover the bearings protrude over the shaft. Covers are placed to protect against dust and dirt. This is followed by inserting and connecting the upper and lower parts of the housing with a screw connection. From the base or Toolbox, a screw (8) and a nut (9) are placed on the appropriate places where the holes are located on the housing.

The final appearance of the reducer assembly is shown in the following figure.

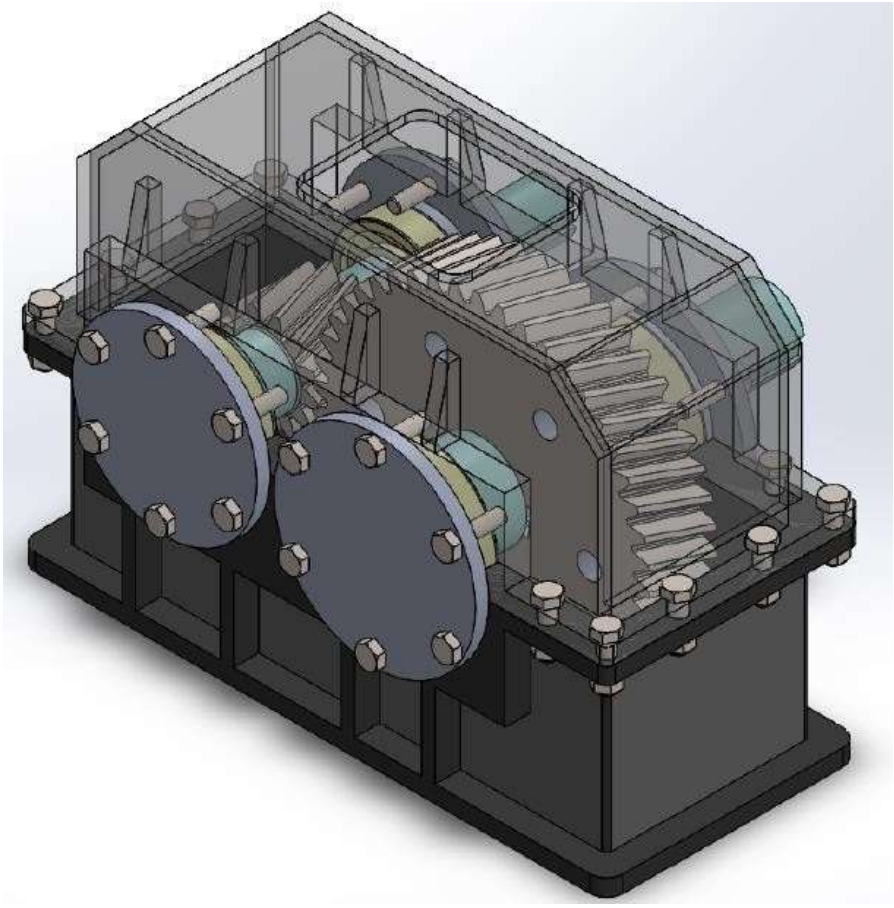

Figure 11. Appearance of the reducer.

The transparency of the upper part of the case has been changed in order to make the internal parts of the reducer visible.

4. Animation

In order to sell the product, it is very important to present it to customers in order to attract their attention and to provide the necessary information about the product they are buying. A presentation of a product can be shown using animation in the SolidWorks program. The animation is a visual representation of the product's operation, its interior and moving parts. Solidworks animation enables the design of complex parts like engines while allowing each part to move in the correct path.

Timeline is a time interface for animation. It shows the time, types of movements and changes in the animation studio. After setting the time indicator to the desired time in the graphic window, changes can be made to that time. The time bar is located above the time sequence and shows the time in which the time sequence is located. At any moment we can see what is happening in the animation. By selecting a motor in which various properties are defined: direction of speed, speed of rotation and acceleration, and contact loads acting on the entire system, the software calculates the load on individual parts. [6]

The timeline layout and engine feature selection options are shown in Figure 12.

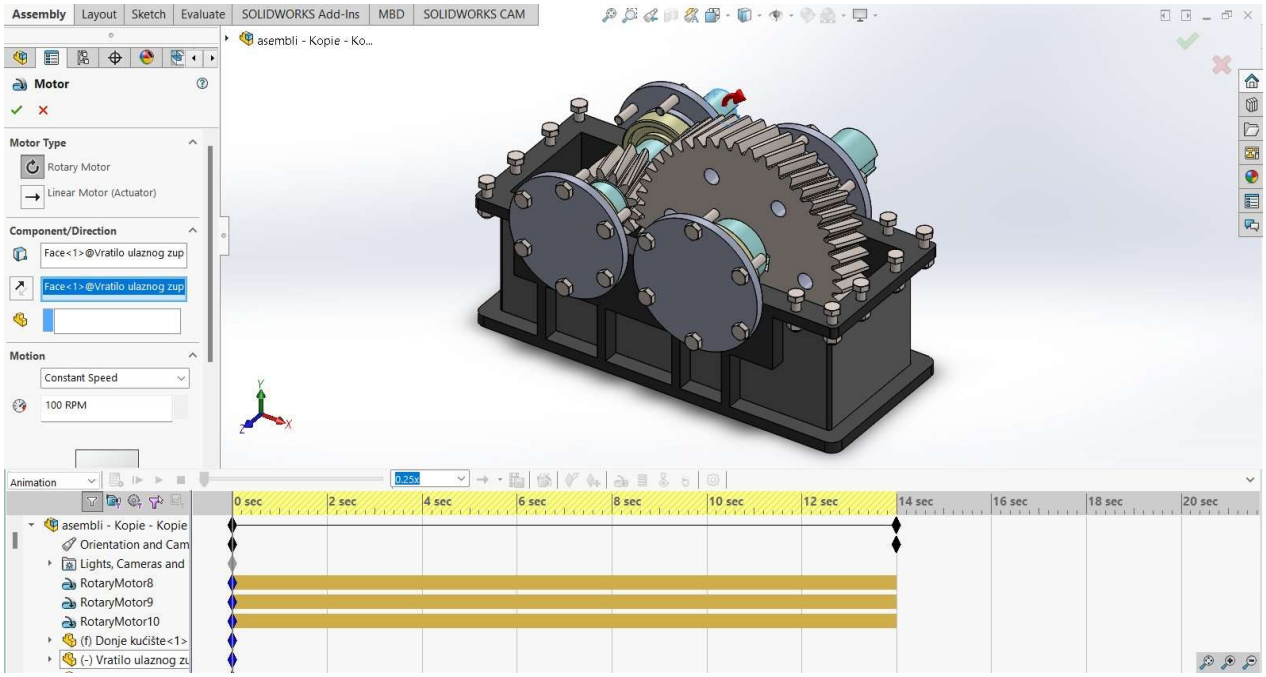

Figure 12. Reducer animation.

There are three ways of creating animation in Solidworks, namely: free animation, automatic movement generation and computer simulations of movement (also called: point by point, motion study, motion analysis) [6].

Free animation means that the object moves from one place to another without any influence from the environment, another object, gravity, and even if that path means that it will be in contact with another object, it will simply pass through that other object. It is most often used on objects that are not loaded. Automatically generated movements are based on connections and relationships between parts. A part can move if its mass changes or if it collides with another part to which a force is transferred. In computer animations of movement, the parts do not have fixed positions between each other, but their position changes due to external influences, their mass, gravity, etc. This way of creating animation is actually the most complex level of movement study, which enables testing of real working conditions for a specific product or construction. [6]

Depending on the need for particular product's animation animation, the most suitable of the three options is to be selected.

5. Conclusion

In the past, the construction process was carried out manually and the recognition of manufacturing errors occurred too late - when the product had already been manufactured. With the increase in the volume of production, the need for faster and simpler software packages intended for the design and construction of machine elements arose. SolidWorks took and still takes an important place in above described. This paper showed the simplicity and adaptability of already existing elements and the use of ready-made standard ones, which significantly reduces the modeling time (i.e. reducer), as well as the possibility of errors. A special advantage is the animation of the assembly, which provides transparency of the individual elements and their mutual position, as well as the working principle of the final product, which provides visualization and clear observation of defects even before the start of production. All the mentioned advantages are observed with the program package SolidWorks, which makes it a compact unit and the first choice of students.

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Design of hydraulic machines with the use of the numerical methods

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Abstract. Problems in the energy field require the daily attention of engineers in the development of new products. This is especially true in the development of power machines, where energy conversion must be as optimal as possible. As the use of renewable energy sources remains very important, research in the field of water turbines is currently significant. Equally important energy machines are pumps, whose operation requires a lot of energy. In the past, the development of rotating machines was based on theory and experiments, but recently numerical methods have been increasingly used. Computational fluid dynamics (CFD) can replace much of the experimental work in the design phase, but these methods face some challenges that still need to be addressed very carefully. In this article, we present the possibilities of using CFD methods in the development of water turbines and pumps, as well as the problems we encounter in the development phase.

1. Introduction

The efficient use of energy and the efficient energy conversion are very important for all energy machines. If we consider the operation of pumps, we find that the number of pumps used in various industries is very high, and the energy consumption is correspondingly enormous. Therefore, when developing different types of pumps, special attention must be paid to energy utilisation and optimal operation of the machines. In the case of turbines, in addition to smooth and long-term operation, the highest possible efficiency is essential. Here, too, it is necessary to take these criteria into account at the planning stage and throughout the development process. In the case of hydraulic machinery, it has long been assumed that a theoretical and experimental approach was sufficient for a quality product. Recently, more and more experimental methods can be replaced by the use of numerical simulations of the so-called Computational Fluid Dynamics - CFD. The development of the CFD methods has experienced a rapid growth since the early 1990s, and the CFD methods have received an additional boost from the rapid development of multiprocessor computers, which can be very powerful and at the same time available for industrial applications. With the rapid development of various commercial software packages (Ansys, Fidelity, Star CCM, etc.) as well as open-source programmes (OpenFOAM) and the evolution of computer capacities, it cannot be said that all previous problems have already been solved. Sometimes it can even be stated that due to the rapid development selected simulations could be performed faster and also the number of individual analyzes can be larger. However, the question of the quality of the results obtained often remains open. As software and hardware enable us to simulate an increasingly wide range of physical phenomena in the field of computational fluid dynamics, this also gives rise to new problems for researchers and engineers.

In this article, we present some of these challenges that require greater attention when performing various CFD analyses if we want to obtain high-quality results and, consequently, high-quality and energy-efficient turbine engines.

2. Basic equations

In all simulations of CFD analyses, a system of nonlinear partial differential equations, the Navier-Stokes equations, is solved. The solution of these equations for real problems is only possible with a suitable numerical method, which requires a discretization of the 3-D region under consideration. For CFD analyses, this is mainly the finite volume method [1]. In order to obtain high quality results, it is necessary to generate computational grids that meet the recommended standards in terms of orthogonality, expansion ratio and aspect ratio. Due to the influence of viscosity and turbulent flow, special attention must be paid to the design of elements near stationary and moving walls. Since the Navier-Stokes equations allow the treatment of turbulence with the so-called direct numerical simulation (DNS), numerical flow problems could theoretically be solved without the use of different turbulence models. However, in such cases, the number of elements in the computational grids would be enormous, resulting in unreasonably long computation times for practical use in basic research and being completely inaccessible for industrial applications. Due to these facts, most CFD analyses use one of the many well-known turbulence models. The most commonly used are the so-called RANS (Raynolds Average Navier-Stokes) or (Unsteady Raynolds Average Navier-Stokes) URANS models, where the Bousinesq assumption is taken into account and a new unknown called eddy viscosity is introduced into the calculation. The eddy viscosity calculation can be performed using algebraic turbulence models, one-equation models, or two-equation turbulence models. In special cases, all six Raynolds stresses can also be calculated. In practice, two-equation models with wall functions or so-called low-Raynolds models are most commonly used. For more complex flows, where nonstationary phenomena dominate, SAS (Scale Adaptive Systems) models [2], which are based solely on nonstationary calculations, have recently become popular. In most other two equation models, it is possible to analyse stationary or nonstationary cases. Calculation times are unreasonably longer in non-stationary cases than in stationary calculations because small time steps are required.

3. Wall Roughness

In most simulations of CFD the smoothness of the walls is considered, which in practise does not always correspond to real conditions. The roughness of the surfaces in some cases affects the quality and accuracy of the results and, consequently, the characteristics of some hydraulic machines. In the analyses of CFD, roughness can be taken into account in several ways. One way is to create an accurate 3-D model of the rough surface and a computational mesh that follows the rough surface. In such cases, the numerical simulation could become very complicated, since a large number of small elements would be required to describe the geometry of the rough surface. Therefore, in such cases, special parameters are usually used to represent the influence of roughness on the results of the analyses. One such parameter is the sand grain equivalent, which must be defined as a function of the size and shape of the roughness. It is mainly given by the size of the roughness in micrometres, but it is not identical with the actual roughness. In this case, it is necessary to determine the relationship between the absolute roughness and the value of the parameter used. The next problem is related to the creation of the computational grid along the wall and the use of an appropriate turbulence model. For any turbulence model, the value of the dimensionless parameter y^+ is recommended, which allows high-quality simulations. Taking into account roughness, the choice of the correct value of the parameter y^+ changes in comparison with standard simulations, so it is necessary to perform additional analyses of the influence of this parameter on the quality of results [3]. When analysing the characteristics of radial pumps with roughness on the walls of the impeller vanes, a different efficiency curve is obtained than without taking roughness into account. This is most evident at higher flow rates, where flow velocities are higher and losses increase with the square of the flow velocity. Figure 1 shows an example of the analysis of a radial pump with smooth and rough walls and a comparison of the results with an experiment on a model.

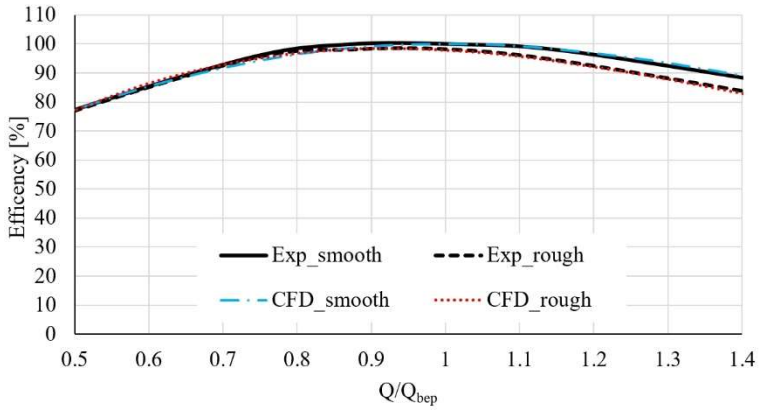

Figure 1. Comparison of pump efficiency for CFD and experimental results.

4. Multiphase flow - cavitation

In hydraulic machines cavitation is a quite common and at the same time undesirable physical phenomenon. Cavitation is a phenomenon in which a liquid evaporates at normal temperature due to a local pressure drop, which is due to the relationship between pressure and velocity in Bernoulli's equation. If we want to reduce the impact of cavitation on the operation of pumps and turbines, we must be able to determine the possible presence and intensity of cavitation during the design phase with numerical analysis. Cavitation is basically a two-phase flow of liquid and gas (vapour). The first problem that may arise with various software packages is the use of an appropriate turbulence model. When analysing cavitation flows, we also need to pay attention to the boundary conditions, since at least at one point we need to know the value of the absolute pressure, which is necessary to determine when the local pressure drops to the value of the evaporating pressure. When analysing cavitation, the location and intensity of the cavitation bubble can be predicted fairly accurately [4]. A larger problem arises when one wants to accurately determine the critical cavitation coefficient of a pump or turbine, or the NPSH characteristic of the pump. Figure 2 shows an example of a numerical prediction of the NPSH characteristic curve of a centrifugal pump and the comparison with a measurement.

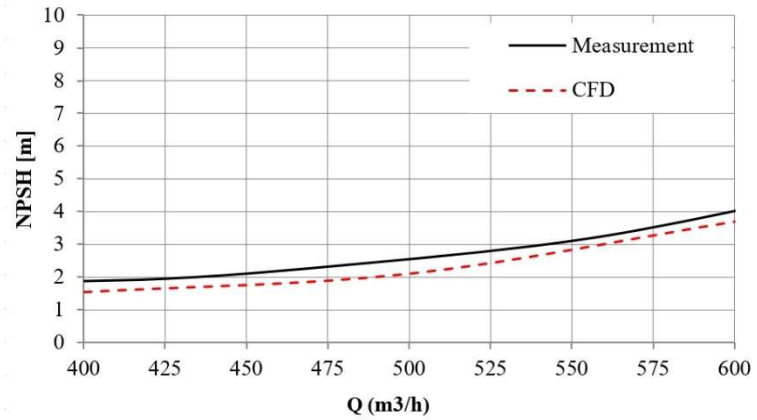

Figure 2. Comparison of NPSH characteristic for CFD and experimental results.

5. Free surface flow

Free surface flows do not occur frequently in hydraulic machines. However, there are some cases where it is necessary to analyse the flow with a free surface. The most typical example is the flow conditions in a Pelton turbine [5], where it is necessary to first calculate the exact shape of a high velocity water jet exiting a nozzle and then the water rebound from the rotating wheel of the Pelton turbine. In this case, the fact that it is not possible to obtain a good result with a steady-state calculation is particularly

important. The second challenge concerns the area where the water and air are located after the jet bounces off, since the computational mesh must be dense enough to describe all the individual droplets of liquid after bouncing off the bucket [6]. If one wants to analyse only a water jet, one can use adaptive grids that automatically thicken at the boundary between the fluids. However, such an approach is not suitable for analysing the flow conditions of the entire turbine. Figure 3 shows the flow field after the water has been deflected by the Pelton wheel.

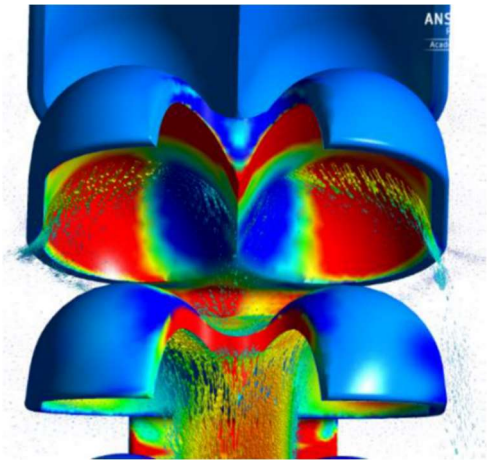

Figure 3. Velocity vectors and pressure distribution - Pelton wheel.

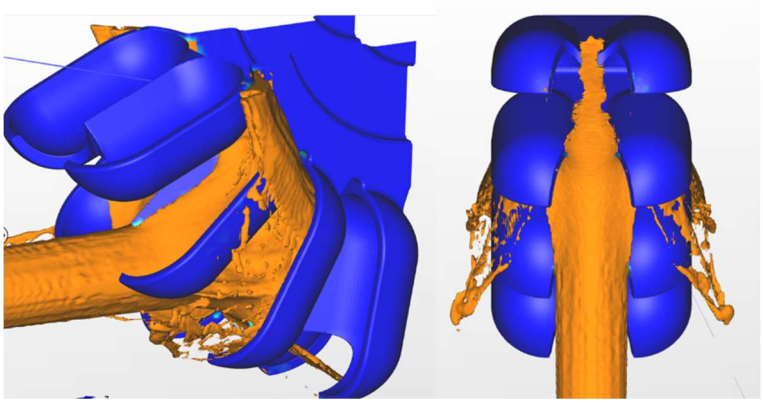

Figure 4. Flow in Pelton turbine.

6. Unsteady analysis

In most industrial applications where CFD is used in the development phase, steady-state calculations are performed. Only these are much faster than if the time course of the physical phenomenon to be analysed is included. However, there are cases where the use of non-stationary calculations is necessary, otherwise the results would be almost useless.

We can point out some cases where non-stationary calculations are absolutely necessary. First, we can look at the operation of the pumps. If we analyse the area near the optimal operating regime, it is generally not necessary to perform non-stationary calculations. However, if we are interested in operating regions with lower or higher flows than optimal, the results are highly dependent on the choice of the calculation model. Figure 5 shows the convergence process for the entire operating range from low to high flows, with the flow increasing as the simulation progresses. It can be seen that the efficiency varies greatly at low and high flows, and it is impossible to determine the true value of the efficiency with a steady-state calculation. The fluctuations range from a few to more than ten percent, which means that such results are completely unreliable [7].

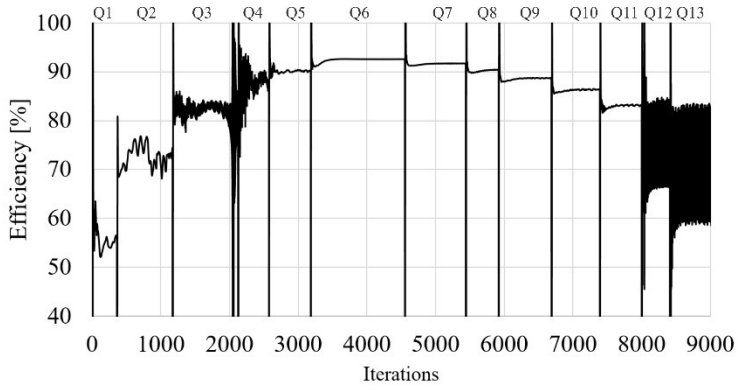

Figure 5. Efficiency of reversible pump turbine (pump mode) for different flow rates.

Based on the results presented, the use of non-stationary calculations to determine the unstable zone in the H(Q) curves of radial pumps is recommended (Fig. 6).

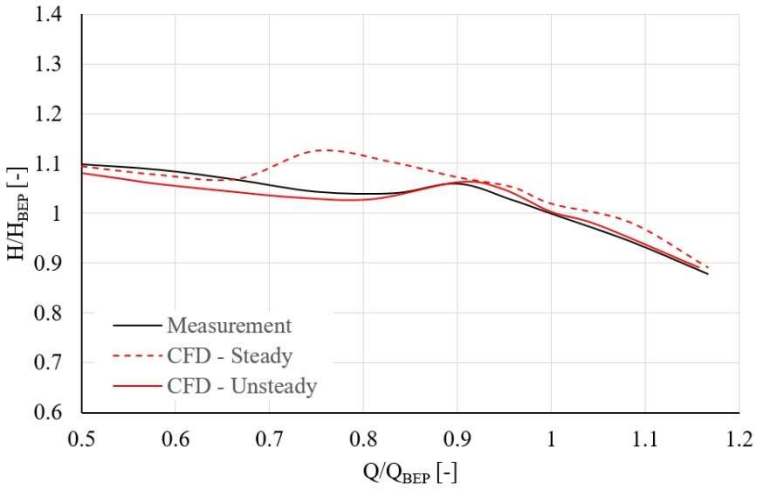

Figure 6. H(Q) characteristic unstable zone analysis.

In the case of turbines, we must use nonstationary calculations when analysing turbines with low heads, especially bulb turbines. In these cases, the efficiency may be calculated incorrectly due to the error in determining the losses in the intake pipe, and the error is more than 5%, which is unacceptable for this type of application. When using transient calculations, the error is significantly reduced to the order of one percent.

When analysing the formation of a vortex rope in the draft tube of radial turbines, one of the basic calculation parameters is the frequency of the vortex, and the amplitude of the pressure fluctuation is also important. If these two parameters need to be determined, the use of unsteady calculations is also necessary in these cases. However, all the above problems are not just about stationarity or non-stationarity, sometimes one has to be very careful in choosing an appropriate turbulence model. When choosing turbulence models, we usually have to make a trade-off between the accuracy of the calculation and the time we need for the analysis. In some cases, it turns out that the most time-consuming turbulence model improves the result only minimally compared to the much more time-saving turbulence model.

7. Conclusion

Numerical methods are increasingly used in the development of hydraulic machines - pumps and water turbines. This reduces the number of model measurements carried out in laboratories. All this forces us to make ever-increasing demands on the reliability and accuracy of the results of numerical methods. The article presents some challenges in the use of CFD analyses, where we have to decide on appropriate computational grids, physical models, turbulence models, and the use of steady-state or non-steady-state simulations, even before the simulations begin. All these decisions require mutual trade-offs and the use of additional parameters to make the final result useful. In the case of pumps, it is useful to monitor the convergence of all possible variables, not just the residuals, in all simulations, as this is the only way to quickly determine which methods and models are appropriate for the simulation. In the case of pumps, the problem of cavitation or NPSH properties often arises, necessitating the use of cavitation models. Due to the physical nature of flow conditions, where the flow globally transitions from a smaller to a larger area, there is a high probability of vortex formation, backflow, and flow detachment. For all phenomena listed, it is important to consider the use of non-steady-state calculations, and for all phenomena listed, it is necessary to consider the adequacy of the turbulence model. In the case of water turbines, the overall flow conditions are more favourable, but due to the different types of turbines operating under very different conditions in terms of the magnitude of the head and the flow rates, it is also necessary in many cases to perform transient calculations with correspondingly small-time steps. Cavitation is also present in almost all types of water turbines. As for roughness, problems often occur in pumps with smaller dimensions, which is a consequence of manufacturing technology. For water turbines, roughness is not a problem that should be addressed. With the rapid development of powerful computers, many of the problems presented above will become insignificant, but as long as we are limited in any way by computational capacity, we will be forced to compromise at the expense of the quality of numerical results. With a detailed knowledge of all the physical phenomena of flow and the theory of numerical simulations, even the compromise results will be good and useful, both in science and in industry.

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Testing of welded structures using the impermeability and penetrant method

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Abstract. The topic of this paper focuses on the non-destructive testing of welded structures, aiming to assess the quality of the final product. The tests were conducted on Fröling boilers from the T4e 35 and TX/TM 250 series, employing the impermeability method and the penetrant method. These testing methods were selected due to their cost-effectiveness and ease of implementation. Additionally, one notable advantage of these methods is the ability to obtain results within a short timeframe, which is particularly valuable in dynamic production environments. The significance of testing welded constructions is substantial as it allows for the identification of potential flaws prior to the product's market release. The ultimate objective of any production process is to deliver a high-quality product that fulfills customer requirements. During the examination of the T4e 35 and TX/TM 250 boilers, which were welded using the MIG/MAG (Metal Inert Gas/Metal Active Gas) process, specific irregularities were detected, indicating unsatisfactory weld quality. Such defects can be attributed to human factors, including inadequate fusion resulting from lower current strength, improper positioning of the welder during welding, and a lack of experience on the part of the welder.

1. Introduction

The paper shows the examination, namely, assessing the quality of welds on the T4e 35 (35 kW) and TX/TM 250 (250 kW) series boilers. These boilers are products of an austrian company Fröling. The examination is carried out using the non-destructive method of testing welds, more precisely, the impermeability and liquid penetrant methods, at Bosnian company Č.J. Non-destructive testing (NDT) is a testing and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or welding defects and discontinuities without causing damage to the original part. NDT also known as non-destructive examination (NDE), non-destructive inspection (NDI) and non-destructive evaluation (NDE). The most common non-destructive tests to check welds are: visual inspection, liquid penetrant, magnetic particle, eddy current, ultrasonic, acoustic emission and radiography. Inspection of welds using the previously mentioned methods (NDT) is of great importance in the supply chain because it also represents the output control of the product. If certain irregularities are established in this way, it is necessary to correct them, which causes undesirable production delays. Impermeability represents the ability to prevent the passage of water or another medium through the welds on the construction.

The impermeability method shows whether the quality assurance measures during welding are effective, and at the same time, it also shows the effectiveness of implementing the statutory welding technology. Liquid penetrant testing is often used when testing welded joints on structures. If the product meets the required criteria, it is prepared for marketing and delivered to the customer.

2. Weld quality testing of the T4e 35 boiler using the impermeability method

Fröling T4e 35 is a compact automatic boiler that uses woodchips or pellets for its drive, that is displayed in the Figure 1. Thanks to the previously mentioned automatic system, this stove can burn pellets or woodchips with as much as 30% moisture. With a silicon carbide combustion chamber, the T4e 35 boiler provides a high level of efficiency (up to 93.7%) with very low emissions. The foundation of this boiler is a welded structure, which consists of 2 segments, namely the outer and inner jacket made of structural steel, welded by the MIG/MAG process.The Impermeability testing is one of the non-destructive quality control methods (NDQM) and is mostly carried out on pressure vessels, and depending on the required quality and the applied regulations, it is carried out by bringing air or water to a certain pressure value or using a vacuum chamber. The previously described method does not affect the functionality of the tested material, so it remains undamaged. [1]

Figure 1. Welded construction of the boiler T4e 35

The main purpose of non-destructive testing is to determine the quality and compliance of the elementary material and welded joints with the requirements of technical specifications and standards, as is the case in this work, the procedure of which will be described in more detail further on.

2.1. Quality assurance procedure for the T4e 35 welded construction

The first step in the testing procedure is to place the boiler above the so-called “abpres”, also known as a place that is exclusively intended for this type of testing because water is used as a medium. Also, a very important step is to check the working pressure of the boiler, which is always marked on the assembly and welding drawing, specifically the operating pressure of the T4e 35 boiler is 4 bar, which is shown in Figure 2.

Work pressure	4 bar
Water content	117 l

Figure 2. Excerpt from the blueprint of the boiler with data on its operating pressure

The next step in this process is to close all entrances/exits, for example pipes and couplings with plugs or valves.

A barometer should be placed at the lowest point of the boiler, as shown in Figure 3.

Figure 3. Setting the barometer at the lowest point of the boiler

The order in which the connections are placed is:
• barometer,
• ball valve with an outlet
• special connection for the Grundfos pump that is displayed in Figure 4.

Figure 4. Grundfos pump

Also, the valve must be placed at the highest point of the boiler in order to eliminate air, as shown in Figure 5.

Prior to filling the boiler with water, it is crucial to assemble the hose on the special connection, which was previously placed on the valve, for example the barometer, and to check both valves (at the lowest and highest points), which must be open.

Figure 5. Valve placed at the highest point of the boiler

In order to regulate pressure in the boiler, it is necessary to use a ball valve with an outlet at the lowest point, while at the highest point of the boiler, such a type of valve is not needed, that is displayed in the Figure 6.

Figure 6. Connecting the valve at the highest point of the boiler to the hose

The valve at the lowest point must be open in order to allow the flow of water, in other words, filling the boiler with it, while the valve at the highest point must be open in order to release air from the boiler.
After all the necessary valves are opened, the furnace is filled with water, while simultaneously a visual inspection of the weld is performed, as well as checking the pressure on the barometer.

The operating pressure of the boiler is 4 bar (picture 2), however, the test pressure is always about 50% higher than the operating pressure, that is displayed in the picture 7.

When the water level reaches the top of the boiler, the valve at the highest point, in other words, the upper valve, is closed, while the lower valve is open, and the water. pressure in the boiler rises to 6 bar. When a pressure value of 6 bar is seen on the pump, at that very moment the valve on it is closed.

Figure 7. Test pressure

After that, the pressure is detected on the pump and on the barometer, which is set at the lowest point.

If the pressures match, it is a sign that the quality of the welded structure is satisfactory, however, this is not the case in this experiment. After a short while, the pressure on the barometer decreased to 4.08 bar, which is an indicator that the quality of the welds on the boiler is not satisfactory and that it is necessary to take certain corrective measures. Further in the paper, there are images showing bad welds on certain parts of the boiler.

The passage of water through the welds, shown in Figures 8 and 9, occurred as a result of an error in the shape of the weld, or rather, a weld overlap.

Figure 8. Passage of water through the welds on the box

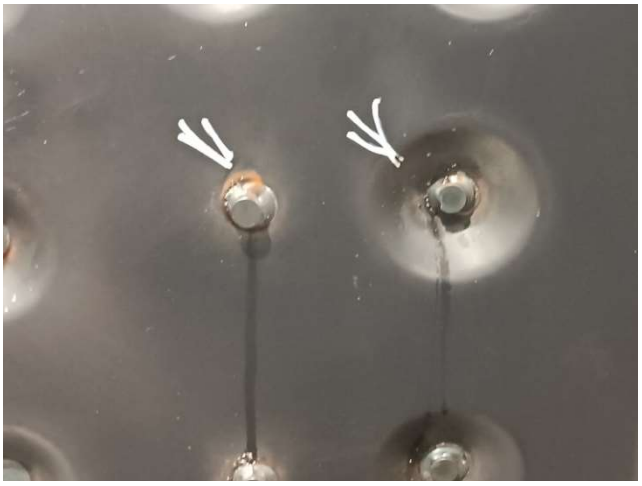

Figure 9. Passage of water through welded anchors (pipes)

An excess of additional material was created, which transferred to the elementary material, but did not merge with it, and for this reason, the water came out. After spotting defective welds, it is necessary to correct them. The pressure in the boiler is set to 0 bar, while water does not need to be removed. If there is a certain value of pressure in the boiler, and at the same time welding corrections are made on it, there is a possibility of an increase in pressure, which would result in the formation of indentations or protrusions on the surface. After the welds at issue are corrected, the entire test procedure is

repeated, until it is determined that all welds on the boiler are impermeable. The next step involves removing the pipes while the valves remain closed on the boiler, which means that there is still pressure below a certain value in it. After that, it is left as such for a minimum of 24 hours. If the proper operation of the boiler is determined after that time, it is ready for delivery to the customer. [2]

3. Testing of the weld quality of the TX/TM 250 boiler by the penetrant method

The Fröling turbomat TX/TM 250, that is displayed in the Figure 10, is a unique heating system with a fully automatic wood burner that works well with different types of wood. Also, this boiler is suitable for using different types of fuel, biomass and wood chips. Aside from being characterized by innovative combustion technology, this boiler also offer impressive control options.

Figure 10. TX/TM boiler construction

All of its functions are fully automatic, from fuel combustion to cleaning and ash removal. This boiler is designed to be extremely durable and at the same time practical to use.

Table 1 shows some of the more important technical specifications of the TX/TM 250 boiler.

Table 1. Technical specification of the TX/TM 250 boiler.

Technical specification	TX/TM 250
Nominal heat output (kW)	250
Flue pipe diameter (mm)	250
Water capacity of the heat exchanger (l)	90
Maximum permissible operating temperature (C)	65
Maximum permissible working pressure (bar)	150/110

3.1. Quality assurance procedure of the TX/TM welded construction using the penetrant method

Penetrant testing (PT) or testing with liquid penetrants is one of the most developed NDT methods. Due to the wide application possibilities and the relatively low cost of conducting the test, this method is widely used.

It is mainly used for metal detection, but also other materials, provided that they are corrosion resistant to the test media and that they are not too porous. Materials that can be examined by PT are metals (aluminum, copper, steel, titanium, etc.), glass, ceramics, rubber and plastic. PT enables the detection of surface defects such as macro and micro-cracks, cavities, porosity, wall permeability, e.g. pipes and vessels, etc. PT is based on the principle of capillary action. The capillary action implies that the bright color penetrant infiltrates into the spaces of the cracks in the object being tested, and after the application of the white color developer, the penetrant comes out of the crack, which greatly improves the penetrant indication. [3]

Ways in which penetrative control makes errors more easily detectable:

- Penetrant control gives an indication of a crack that is much larger and more noticeable than the actual crack,
- Penetrant control improves crack detection which indicates a crack with a higher level of contrast between the indication and the substrate which helps to make the indication easier to see.

PT indicators:

- Concentration of red dots: porosity and pitting,
- Sudden redness, flat, continuous,
- Big cracks,
- Broken lines,
- Small cracks and
- A series of red dots forming an irregular line: the effects of fatigue.

Penetrant weld testing flows in several steps:

- Surface preparation,
- Penetrant application,
- Developer application and
- Visual inspection of penetrant indications. [4]

The surface on which the penetrant is applied must be cleaned up, and it is necessary to remove all impurities such as dust, grease, paint, etc. If the previously mentioned impurities are not removed from the tested surface, they can cover existing cracks, i.e. if the surface is not cleaned properly, indications may appear in places where there are no cracks or indications may not appear in places where there are cracks. When preparing the TX/TM 250 boiler for penetrant control, the surface is first cleaned with a steel brush, that is shown in the picture 11.

Figure 11. Surface cleaning with a steel brush

An air compressor is used to completely remove impurities, that is displayed in the picture 12.

Figure 12. Surface cleaning with compressed air

The penetrant is applied on the previously cleaned surface, in this case with a brush, that is displayed in the figure 13. During the application, it is necessary to precisely apply the optimal amount of the penetrant. After the penetrant application, it is required to wait for a particular amount of time (usually 15 minutes) so that it has the possibility of penetrating into the pores or cracks of the weld. It is important to emphasize that the penetrant in this case is applied from the inside of the boiler.

Figure 13. Application of the penetrant to the internal impermeable welds

After the application of the penetrant, a developer is applied on the outer welds, that is to say, opposite to the penetrant application. The developer, which is white, has the purpose of forming a contrast with the colored penetrant used. The result of the application of the developer is that the penetrant from the cavities emerges more from the cracks, so a penetrant indication is created.

The weld in the Figure 14. turned out to be of insufficient quality, and the cause of the error is insufficient melting between the elementary metal and the weld.

Figure 14. Detection of penetrant indications

This kind of error occurs as a result of the poor work technique of the welder and a weak welding current.

4. Conclusion

The control of welded joints is a key segment in the field of mechanical engineering which has the aim of ensuring high-quality welds that meet the requirements of customers and users. In order to detect possible errors before the product is launched on the market, welding tests are crucial. Two non-destructive testing methods of welded joints are described in detail in this paper, namely the impermeability method and the penetrant method, which were applied on two different boilers. The aforementioned methods have proven to be easy to apply, affordable, relatively fast, and among the most commonly used test methods.

The results obtained by applying these methods on T4e 35 and TX/TM 250 boilers are not satisfactory because certain errors occurred during the welding process, as a result of human action. Problems arose already during the preparation of the examined surface, which was not adequately cleaned. Also, inadequate positions during welding, lack of experience and unsuitable current strength contributed to the unsatisfactory quality. To ensure the quality of the welded joints, it is necessary to correct the low-quality welds, thus enabling further procedures of the product in order to deliver it to the customer. Therefore, improving the control of welded joints is of crucial importance for achieving high quality welded constructions.

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Factors Affecting the Strength of Finger-Jointed Wood Bonded Joints

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Abstract. The aim of this study is to describe and understand the most important factors affecting the strength of wood bonded joints with a finger joint. To achieve high strength and durability of such joints, it is necessary to understand the technological properties of the adhesive and to manage the bonding process properly. The shape, size, and loading mode are also crucial for achieving the final effect of the bonded joint. In this study, we will describe the shape, size, and loading mode of the test specimen for strength testing of the joint.

1. Introduction

Solid wood can be tested for its tensile strength through the use of finger joint, which allows for the determination of its durability, quality, and suitability for a specific use. Solid wood has a wide range of applications, including serving as basic structural elements or as finished products. However, given the different working conditions that solid wood may encounter, such as mechanical, thermal, and chemical effects, it is crucial to select wood with appropriate characteristics, such as the necessary strength, durability, safety, and economy. In modern industrial production, the finger joint connection technique has gained widespread acceptance, and it is predicted that longitudinal joining of solid wood elements will become increasingly important in the wood products industry. This is due to the growing demand for modern structural solutions that can effectively utilize wood raw materials while still ensuring rational processing and the production of high-quality products. The bonding strength of toothed joints is a crucial technical property of longitudinally bonded elements. Therefore, it is important to give special attention to the correct selection of gearing. In this paper, investigations on the tensile force of fracture of toothed joints made of beech and oak are presented, and the influencing parameters are wood density (□), the ratio of width and thickness of wood (w/h), and the geometric size of the mini tooth expressed by the ratio of tooth length and width (l/p) [1]. Several authors [2, 3, 4] have explored different aspects of the strength of toothed joints from a theoretical perspective, applying experimental research and mathematical modeling to numerical simulation. The ultimate goal has always been to enhance the efficiency of the process and make it more predictable. When toothed joints were first used in structural solutions, the strength sample used was of the type with the passage facing up and down, and the joint located in the center of the length [4, 5]. Special equipment and clamps were required for the production of this type of joint. The test sample was developed by Selbo [6, 7], and the assessment was carried out by Bohannan and Selbo [8]. The strength of a toothed connection in solid wood is determined by crucial parameters such as the height, length, thickness of the tip, and slope, which were highlighted in a research paper [9]. Earlier studies on toothed joints involved authors who utilized the finite element

method (FEM) to model the ultimate pressure, modulus of elasticity, and bending strength of wooden joints made of pine [10, 11]. However, the FEM applied to the ultimate pressure tests showed a narrower range in comparison to the modeling results. In another research study [12], mathematical modeling and optimization techniques were employed, where the primary purpose of process and system modeling was to define mathematical models and other representations that accurately describe the studied process/system with an appropriate degree of precision.

2. Testing the strength of adhesive joints

2.1. Impact parameters on the strength of adhesive joints

When bonding materials, it is crucial to achieve a strong adhesive joint that can maintain its strength over time. This is especially important when bonding wood, as the joint should not weaken more than the wood itself during use. Creating a bonded joint is a complex process that relies on preserving the adhesive and cohesive forces over an extended period of time to ensure its safety and durability.

The strength of toothed adhesive joints is dependent on several parameters that have a significant impact, including tooth geometry, joint orientation in relation to the joint plane (vertical, horizontal, or angled), material type and its properties (density, quality, and moisture content within the range of 6-14% for bonding), tooth production quality, adhesive type and its characteristics, technological parameters that affect adhesive hardening (temperature and pressure during pressing and joining), and joint use conditions (type and duration of loads, temperature, and relative humidity of the surrounding air).

Knowing and understanding these influential parameters is crucial for ensuring strong and durable joints that can withstand the intended loads. Only by carefully considering and aligning all these factors, including wood and adhesive preparation, can optimal results be achieved when creating toothed adhesive joints.

2.2. Joining with a toothed connection

Today, the technique of longitudinal joining with a toothed connection has been widely accepted in industrial production. This method aims to increase the value of wood material which, in new structural forms, has improved physical and mechanical properties compared to solid wood. It is predicted that longitudinal joining with solid wood will become increasingly important in the wood industry, due to the increasingly complex demands for shaping modern structural solutions that contribute to the utilization of wood material, its rational processing, and application in the production of high-quality products.

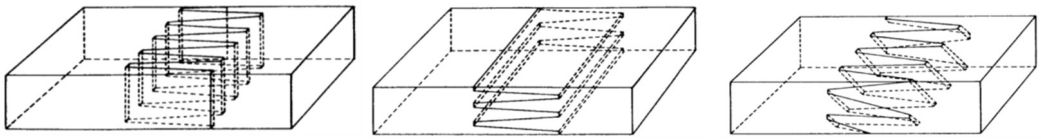

Figure 2. The orientation of the finger joint with respect to the connection: a) vertical, b) horizontal, c) at an angle (45°).

2.3. Adhesive and adhesive quality

Adhesives are substances that allow materials to be bonded together by creating a strong, cohesive bond. This can occur through various mechanisms, such as chemical reactions or physical interactions, depending on the type of adhesive used. The primary function of adhesives is to provide a means of joining two or more materials together that may not be compatible with traditional mechanical fasteners or welding techniques.

The most common type of adhesive is a polymer-based material, which can be either natural or synthetic. These adhesives consist of a binder or resin, which is the primary component responsible for bonding the materials together. Other components, such as solvents, fillers, and additives, may also be added to modify the properties of the adhesive or to facilitate the bonding process.

One of the key advantages of adhesives is their ability to create a strong, durable bond between different types of materials. This allows for the creation of new materials or structures that would be difficult or impossible to achieve using other methods. Adhesives are also highly versatile, and can be used in a wide range of applications, including construction, automotive manufacturing, electronics, and medical devices.

However, the quality of adhesive bonding can be affected by a number of factors, such as the type of materials being bonded, the conditions under which the bond is formed, and the presence of contaminants or other substances that may interfere with the bonding process. Therefore, it is important to choose the right adhesive for a given application, and to carefully follow the manufacturer's instructions for preparation and application.

The classification of thermoplastic wood adhesives for non-load-bearing building structures is presented in the "Table 1: Resistance classification of adhesives from the application perspective." Wood adhesives are always classified based on their origin, chemical composition, method of application, bonding method, properties, and more. However, the best and simplest overview is provided by the classification based on origin and chemical properties. According to origin, adhesives are divided into groups of natural (proteins-based adhesives, polysaccharide-based adhesives, asphalt adhesives, water glass) and synthetic adhesives (polycondensation adhesives, polymerization adhesives, and adhesives based on polyaddition products).

Adhesives can be classified based on their bonding methods, which are determined by the processing and preparation method. There are three types of bonding methods: cold bonding (15-25°C), and warm bonding (50-80°C), and hot bonding (80-160°C).

In the wood industry, adhesives are categorized based on their intended use, which includes:

- adhesives for joining solid wood components and for assembly,
- adhesives for producing particleboard,
- adhesives for producing fiberboard,
- adhesives for producing laminates,
- adhesives for producing laminated structural beams,
- adhesives for bonding laminates, foils, and other materials.

Table 1. View of the place of application of the glue from the point of view resistance [16].

Group	Conditions	Examples of use
D1	Bonding that is stable under indoor conditions with average low humidity is not directly exposed to external conditions	Interior furniture and carpentry works in dry conditions
D2	Bonding that is stable under indoor conditions with high and fluctuating humidity and occasional exposure to water	Applications similar to the D1 group, but in kitchens and bathrooms
D3	Bonding that may be exposed to the effects of humid climatic conditions	Structures made of external wooden products (external doors and windows)
D4	It is used as a D3 group for long-term bonding with resistance to the effects of water and atmospheric conditions	Wooden parts for outdoor use particularly exposed to adverse weather conditions (painted or varnished windows, external cladding) and also for indoor use under extreme conditions

2.4. Interaction of adhesive and wood

Wood gluing involves firmly bonding two wooden surfaces together with adhesive, creating a strong surface connection. A thin, optimal layer of adhesive is applied between the wooden surfaces. Due to the porous nature of wood, the adhesive seeps into the wood pores and hardens, resulting in a network of tiny branches within the pores of both wood surfaces. When bonding or gluing wood, attractive forces known as cohesion and adhesion interact to form chemical-mechanical bonds that provide strength to the resulting joint. Cohesion refers to the force that holds together molecules of a liquid or solid substance. Therefore, when gluing wood, the adhesive and the wood must be in close contact under external pressure while the adhesive is still in its liquid state. It's essential that the adhesive layer wets the wood and penetrates its structure, creating contact between the two substances. If the adhesive doesn't wet the wood, repulsive forces will be generated between the molecules, leading to the creation of dispersion forces. Wood adhesives are typically colloidal solutions that transform from a liquid to a gelatinous state during the gluing process and then harden, resulting in a solid adhesive joint.

This joint may be reversible if the adhesive layer dissolves in water, or it can be permanently strong. The penetration of adhesive into the wood pores depends on the viscosity of the adhesive, the size, and duration of pressure applied. Viscosity quickly decreases as temperature increases, so maintaining optimal viscosity is important for all types of applications during the gluing process. The manufacturer's instructions should clearly define the most critical information for the gluing process. For the process of wood gluing, it is very important to consider the so-called "moistening of the wood." Wood is hygroscopic, capillary porous, anisotropic, and polar material, which is very significant for gluing. Since gluing cannot be achieved without moistening the surface being glued in the gluing process, the moistening of the surface, or spreading the glue over the surface of the wood to which it is applied, is the most important condition for successful and high-quality gluing. It is essential that the polymer - adhesive in liquid form has high adhesion to the wood and wets it, of course, when it comes to liquid glue. In production practice of wood gluing, sometimes, albeit very rarely, non-liquid adhesives (films) are used. However, even such adhesives in the gluing process must go through the liquid phase because without it, there is no gluing of wood.

The rheological properties of the materials involved in the gluing process are very important for gluing, especially after the gluing process is finished, the glue has hardened, and the bonded joints are put into operation. Therefore, the long-term quality stability of the bonded joints largely depends on the rheological properties of the wood at the interface of the joint with the adhesive and the hardened film of the adhesive. Rheological properties of the liquid adhesive are very important for the successful and easy application of the adhesive. Then, changes in the rheological properties of the adhesive during the gluing process and the formation of an adhesive bond with the wood are important, as well as the final properties of the adhesive when it hardens, and any changes in properties during the long-term exploitation of the joints.

For successful and high-quality gluing and for obtaining bonded joints of stable quality, it is essential that the hardened adhesive in the joint has approximately the same rheological properties as wood. Therefore, special attention must be paid to the preparation and selection of adhesives and the preparation of wood for gluing.

Therefore, for achieving quality gluing, the proper selection and preparation of adhesive and wood, suitable equipment and gluing regimes, and ensuring adequate viscosity for the time the prepared adhesive is used, the application of an appropriate amount of adhesive to the surfaces being glued, open time - the time from the moment of applying the adhesive until contact is made between the surfaces being glued, the application of external pressure during gluing to achieve full contact between the surfaces being glued, gluing time - the time from the moment of achieving contact to the moment of releasing pressure, and the time and conditions of acclimatization of the bonded joints are very important.

3. Processing of wooden elements on machines

The surfaces of the lamellae that are glued are processed by planing - cylindrical milling, which must ensure a small surface roughness and an appropriate depth and length of the cycloid trace that arises from the tool during wood planing. In order to ensure as little internal stress as possible in the glued joint, the depth of the tool trace should be h ≤ 0.020mm. Starting from this, and the characteristics of the machine on which the wood is processed, the depth h and length I (tool trace) can be determined from the following formulas:

$$U_n = I\frac{U}{n+z} \tag{1}$$

where:
U = feed rate [m/min]
Un = feed rate per one knife of the cutting head [m/min];
n = speed of the cutting head [rev/min],
z = number of knives on the cutting head;
I = length of the shaft - cycloid trace [m].

The number of blades on the cutting head can range from 2 to 8, but due to variations in tool preparation and blade adjustments, there can be differences in the circles that individual blades describe. To account for this, only one blade (U1) is considered in the calculation, resulting in equation (1) taking on the following form:

$$U_1 = I\frac{U}{n} \tag{2}$$

The equation below can be used to calculate the depth of the wave and the trace of the cutting tool:

$$\boldsymbol{h = \frac{I^2}{8R}} \tag{3}$$

where:
R - radius of the circle described by the cutting tool blades [m].
Knowing the value of I, since h ≤ 0.025mm, the allowable material displacement on the machine during processing can be determined by the equation:

$$U_d = U * n \tag{4}$$

The way in which the laminated lamellas are stacked can have a significant impact on the quality of the glue bond and internal stresses within the glued layer. Incorrect stacking of lamellas can result in destruction - breakage of the glued joint - due to changes in humidity during the use of the carrier wood and resulting swelling and weighting. Such destruction is caused by internal stress within the joint, which can cause it to break due to the glue or the wood along the boundary layer of glue. During planing, the lamella surfaces must be properly ground to ensure that planing does not leave unevenness or elevations in the harder parts of the year compared to the softer parts, as these bumps can create large internal stresses in the glued layer. It is recommended to glue the lamellas no later than 2-3 hours after planing, and the surfaces must be completely cleaned of dust and free of oils or fats.

4. Conclusion

This paper analyzes the importance of parameters for joining solid wood with a toothed joint. It has been shown that for a quality joint, the key is the preparation of wood, the precise determination of the dimensions of the toothed joints, proper application of adhesive, and the use of appropriate tools and wood processing techniques. In addition, it has been found that improper placement of lamellas and unevenness after processing can lead to the creation of internal stresses in the joint, causing damage.

Therefore, it is important to adhere to recommended wood processing and joining procedures to ensure a long-lasting and reliable toothed joint.

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Application of AHP method for multicriteria decision making on the example of ranking students

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Abstract. This paper describes the application of the AHP (Analytic Hierarchy Process) method for multi-criteria decision making in the process of ranking students based on different criteria such as academic performance, income, year of study, and others. Additionally, the paper includes the development of a web application that allows for easy and fast evaluation of candidates and automatic generation of the final ranking based on the assigned importance of each criterion. The first part of the paper describes the AHP method and its application in multi-criteria decision making, with an emphasis on its advantages and disadvantages. Furthermore, the process of selecting criteria and their importance and ranking are described. In the second part of the paper, the development of the web application that facilitates the student evaluation process, calculation of the weighting coefficients of the criteria, and generation of the final ranking order is explained. In the practical part of the paper, a case study of student ranking is conducted where students are evaluated based on several criteria. The data is analyzed, and the importance of each criterion is assigned, and the final ranking order is generated. The results show that the AHP method is useful for decision making in complex situations that involve multiple criteria. Finally, the developed web application can be useful in various fields where similar multi-criteria decision-making problems arise, and its use can speed up the evaluation process and the final decision-making.

1. Introduction

In this research, we focus on the application of the Analytic Hierarchy Process (AHP) as a multicriteria decision-making method for student ranking. AHP is a mathematical technique developed for decision-making situations involving multiple criteria and preferences. This method provides a structure for quantifying subjective judgments and calculating the relative importance of criteria to obtain a final ranking.

In addition to the application of the AHP method, this research explores the implementation of a software solution for student ranking. Introducing software into this process can facilitate and automate the ranking procedure, eliminate potential errors in manual calculations, and enable a faster and more efficient decision-making process. Moreover, the software can provide additional capabilities for data analysis and generate relevant reports.

In the following sections, we will describe in detail the theoretical background of the AHP method and explain the steps involved in implementing this method for student ranking. We will also present our software solution, describe its functionalities, and explain how to use it. After conducting the research,

we will analyze the results to assess the effectiveness of applying the AHP method and evaluate the efficiency of the software solution.

2. The Analytic Hierarchy Process (AHP)

The term "analytical" signifies that this method use numbers, "hierarchical" indicates that the AHP model establishes goals, criteria, sub-criteria, and alternatives, while the term "process" denotes problem-solving in a specific continuum [1].

In recent years, the AHP method has gained popularity and become one of the most commonly used methods because it mimics the way individuals solve complex problems by breaking them down into simpler components. It was developed by Thomas L. Saaty in the 1970s. The method assists decision-makers in solving complex multi-criteria decision-making problems. When using this method, the decision-maker independently sets criteria by importance and based on them, selects the best alternative, which is the primary objective of the model itself. The AHP method has broad applicability. "T. Saaty identifies situations in which AHP can be used: personal decisions, socio-psychological field, business, nonprofit agencies, public policy issues, international context, assessment/prediction" [1].

The main mathematical tool used in the AHP method is matrices. The element aij of matrix A represents the relative importance of criterion i with respect to criterion j. If n is the number of alternatives or criteria whose weights or priorities w need to be determined based on the assessment of their value ratios, they are denoted as follows [2]:

$$a_{ij}=\frac{w_i}{w_j} \tag{1}$$

From the above, the relative importance relationship matrix A is derived:

$$A=\begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix}=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{2}$$

In the case of consistent estimates, $aij = aik \cdot akj$, which fulfills the condition of the equation: $A \cdot w = n \cdot w$, where w denotes the priority vector **Error! Reference source not found.**.

$$\begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & w_n \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix}\begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}=n\begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \tag{3}$$

The matrix A is a positive reciprocal matrix because of the elements that satisfy the condition of the equation:

$$a_{ij}=\frac{1}{a_{ij}} \tag{4}$$

The element above the main diagonal is equal to the reciprocal of its symmetrical element below the main diagonal. The matrix A has rank 1 ($r(A) = 1$) and has an eigenvalue equal to n. Since the sum of the eigenvalues of a positive matrix is equal to the trace of that matrix, the non-zero eigenvalue has the value n [2]:

$$\lambda_{max}=n \tag{5}$$

Since any deviation from consistency affects the change of eigenvalues, the consistency index *CI* was defined using the AHP method [3].

$$CI=\frac{\lambda_{max}-n}{n-1} \quad (6)$$

λ_{max} denotes the largest value of the comparison matrix, while n is the number of criteria or alternatives being compared. The smaller the difference between λ_{max} and n, the consistency is higher.

$$CR=\frac{CI}{RI} \quad (7)$$

The consistency ratio (*CR*) is calculated by dividing the consistency index (*CI*) by the random consistency index (*RI*). If the consistency ratio is 0.10 or less, then the assessment, that is, the decision maker's answer is consistent, but if the consistency ratio is higher than 0.10, it is necessary to investigate why the inconsistency occurred.

3. Application of Analytic Hierarchy Process Method to the ranking of students

Multicriteria decision making is a decision-making method in which various factors (or criteria) are taken into consideration to rank individuals, organizations, or projects. This research involves the investigation and implementation of a software solution for the problem of ranking students applying for scholarships. In the context of scholarship applications, multicriteria decision making can be applied to determine which students will be awarded scholarships. In the problem of multicriteria decision making, the following terms are used to describe and differentiate alternatives:

1. Set of Alternatives A = {a1, a2, ..., an}
2. Attributes - the characteristics or properties of each alternative that are relevant to achieving the goal or solving the problem. Each attribute is a function (f1, f2, ..., fk) that assigns a certain value to each alternative.
3. Criteria - numeric functions that need to be maximized or minimized. The criteria fj can be benefit criteria (higher value is better, e.g., profit) or cost criteria (lower value is better, e.g., price of goods or services). In the decision-making problem, not all criteria need to be equally important. Therefore, weights or relative values (weights) w1, w2, ..., wk are assigned to them.
4. Objectives - predefined values of certain indicators or levels that we want to achieve.

The decision-making problem is to identify the alternative that is the best with respect to all criteria. Accordingly, we can construct a table, according to Table 1, which represents the formal notation of multicriteria decision making. This table contains data about the alternatives that are relevant for decision-making. In addition to the header, the table has as many rows as there are alternatives and as many columns as there are criteria used to evaluate them. The table also includes weights or relative values of criteria w1, w2, ..., wk.

Table 1. Formal presentation of alternatives and criteria.

	$f_1(.)$	$f_1(.)$	...	$f_1(.)$	...	$f_1(.)$
	w_1	w_2	...	w_j	...	w_k
a_1	$f_1(a_1)$	$f_2(a_1)$	...	$f_j(a_1)$	...	$f_k(a_1)$
a_2	$f_1(a_2)$	$f_2(a_1)$	...	$f_j(a_2)$	...	$f_k(a_2)$
...	...	...	...	...	...	...
a_i	$f_1(a_i)$	$f_2(a_i)$	...	$f_j(a_i)$	...	$f_k(a_i)$
...	...	...	...	...	...	...
a_n	$f_1(a_n)$	$f_2(a_n)$	...	$f_j(a_n)$	...	$f_k(a_n)$

Table 1 shows a formal record of multi-criteria decision-making for an example of ranking students registered in the scholarship competition.

Table 2. Alternatives and criteria.

	Year of study	Success in the previous year	Number of household members	Parental disability	Illness of members without disability resolution	A student without one parent	Student of unknown paternity	Divorced parents or student single parent	Number of students from the household	Number of students in primary and secondary schools	Monthly income per household member
Weights	w_{gs}	w_{u}	$w_{bčd}$	w_{ir}	$w_{bčbi}$	w_{sbr}	w_{no}	w_{rsr}	w_{bsd}	w_{bu}	$w_{ppč}$
Criteria type	max	max	max	max	max	max	max	max	max	max	min
Unit	-	-	-	-	-	-	-	-	-	-	BAM

In order to perform calculations with such diverse data using the multicriteria decision-making method, it is necessary to perform a procedure called normalization, which involves converting the criterion values from the decision table into comparable scales. In the normalization process, it can be assumed that all criteria are benefit criteria. In the case of cost criteria ("the lower, the better"), the criterion values are first replaced with their reciprocal values, and then these values are normalized. Normalization can be done in various ways, and in this case, percentage normalization was used (using the maximum criterion value, as shown in formula 7). Each element of the decision table is divided by the maximum value in the column to which it belongs. This yields relative values in relation to the value of the best alternative for the observed criterion. Usually, this value is expressed as a percentage, and normalization is performed using the formula:

$$r_{ij}=\frac{f_j(a_i)}{\max\limits_i f_j(a_i)} \tag{7}$$

It is obvious that $0 \leq r_{ij} \leq 1$, the score is better if r_{ij} is closer to 1.

The next step is the process of converting the criteria into benefit criteria, meaning "the higher, the better." For values representing cost criteria, we calculate the reciprocal value. After calculating the reciprocal value for the cost criteria, the normalization process follows, which in this case is done using the "percentage normalization" method. Based on the available data, it is possible to determine which offer is the best, assuming that all criteria are equally important. All criterion data has been transformed into "higher is better" values and can be compared as they have been scaled within the range of 0 to 1. Criterion values can be summed to obtain a total value for each offer, although they are usually normalized by calculating the proportion to the sum of values of all offers in order to obtain the final ranking [4].

Next, we will describe the procedure for calculating criterion weights, which is very straightforward. To assess the importance of criteria, we will use Saaty's scale, which is used for evaluating decision alternatives but also applied to establish priorities among alternatives with respect to the criteria being compared. The criteria are compared using values from 1 to 9 according to the table below.

Table 3. A comparison matrix can be built based on the Saaty Rating Scale.

Intensity	Definition	Explanation
1	Equally important	The two criteria or alternatives contribute equally to the goal.
3	Umjereno važnije	Moderately more important
5	Strictly more important	Based on experience and judgment, one criterion or alternative has a strong advantage over another.
7	Very strict, proven relevance	One criterion or alternative is strongly favored over another; their dominance is proven in practice.
9	Extreme importance	Evidence favoring one criterion or version over another has been established with the greatest certainty.
2,4,6,8	Intermediate values	

The next step is to construct the criterion ratio table based on Table 3, which represents the relative weights between each criterion. Based on this data, a weight matrix is formed 0. This matrix, denoted as A, has an element in the i-th row and j-th column representing the weight ratio between the i-th and j-th criterion. This ratio is denoted as aij and satisfies $aij = wi / wj$. The procedure for calculating approximate values of criterion weights (priorities) based on the estimated ratios of their significance is performed in three steps:

- The column sums of the estimated criterion ratio matrix are calculated.
- The matrix is normalized by dividing each element of a specific column by the sum of that column.
- The criterion weights (priorities) are obtained as the average values of the row elements in the normalized matrix.

This procedure is approximate but provides reasonably accurate solutions if errors that may lead to excessive inconsistency in the estimations are avoided. It is usually applied in cases where a smaller number of criteria or alternatives are being compared [5].

4. Development of a web application as a support for solving the problem of student ranking using the AHP method.

The development of a web application for solving the problem of student ranking in scholarship competitions is a valuable tool for organizers and students applying for scholarships. The application would provide an easy way for students to submit their applications and process the data they provide, automatically calculating a ranking based on the set criteria. The application includes functions such as creating student profiles and applying through a form that contains relevant information such as grades, year of study, monthly income, and other pertinent data for the scholarship competition. Customization of selection criteria for students, such as grades, extracurricular activities, and financial support. Automatic calculation of the ranking list based on the entered data and set criteria, with the ability to view, sort, and filter application data. It is also possible to rank students without assigning weighted values to the criteria. The web application was developed using the Angular framework and, as such, represents a useful software solution as it enabled the development of a modern, scalable, and fast application.

4.1. Home page

The homepage of the web application for solving the student ranking problem in the scholarship competition includes a brief overview of the problem, a brief explanation of the method used for evaluating alternatives, and instructions for using the application. All pages of the application share the same navigation section and header. Each section of the page is clearly labeled, allowing users to

navigate through the application easily. Additional content and features can be added after the initial development of the page, depending on the needs and preferences of the users.

Figure 1. Home page.

4.2. *Student entry and review page*

The student entry page represents a form for entering data about students applying for the scholarship. On this page, students can enter their first name, last name, year of study, GPA, performance in the previous academic year, and other relevant information required according to the published competition guidelines.

The form is user-friendly and suitable for fast data entry. After the user enters all the necessary information and clicks the "Submit Student" button, the data is saved in the database, and a message is displayed to the user indicating successful or unsuccessful entry. This page helps competition organizers gather all the necessary student information in one place and facilitates the process of ranking scholarship applications.

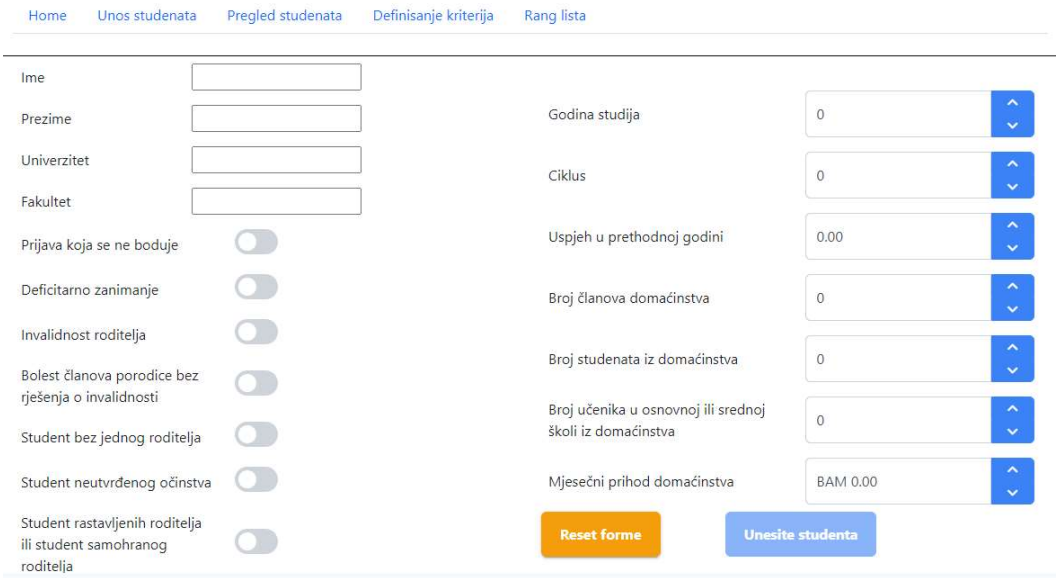

Figure 2. Student entry page.

After students have been entered into the database, on the "Student overview" page you can see a table of all students who have been entered into the database, i.e. registered for the competition. The table contains basic data about students, but also the option to remove a student from the database.

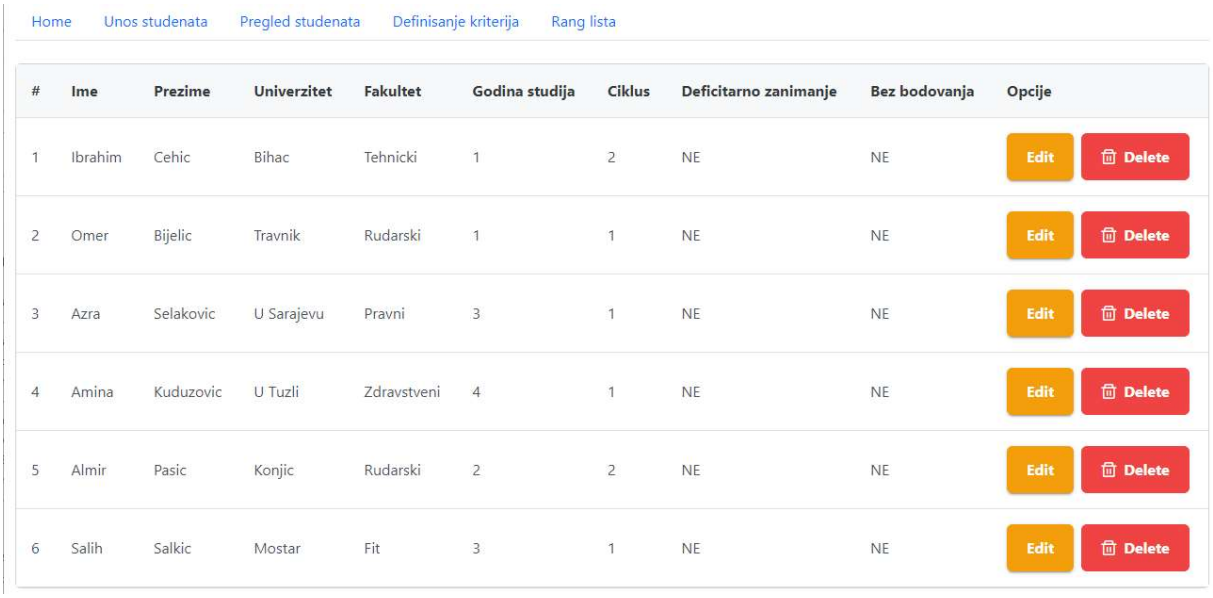

Figure 3. Page with entered students in the database.

4.1. Criteria definition page

This page is used to define the criteria by which students will be ranked in the scholarship competition. On this page, competition organizers can define the criteria that will be considered when selecting students. The form contains fields for defining the criterion name, criterion description, and the criterion's importance relative to other criteria. Once all the criteria are defined, clicking the "Calculate Alternative Values" button will save the data to the database.

Saatyeve ljestvice formira se tablica (matrica) uporedbi kriterija

	wgs	wu	wbčd	wir	wbčbi	wsbr	wno	wrsr	wbsd	wbu	wppč	ciklus
wgs	1	3	4	8	2	2	2	3	1	1	1	1
wu	0.333	1	4	1	1	1	6	2	1	2	1	1
wbčd	0.25	0.25	1	1	3	2	1	2	1	4	2	6
wir	0.125	1	1	1	1	1	1	2	1	1	2	1
wbčbi	0.5	1	0.333	1	1	1	1	2	1	1	6	2
wsbr	0.5	1	0.5	1	1	1	5	1	1	1	1	2
wno	0.5	0.167	1	1	1	0.2	1	1	1	5	2	1
wrsr	0.333	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1
wbsd	1	1	1	1	1	1	1	1	1	1	1	1
wbu	1	0.5	0.25	1	1	1	0.2	1	1	1	5	2
wppč	1	1	0.5	0.5	0.167	1	0.5	1	1	0.2	1	1
ciklus	1	1	0.167	1	0.5	0.5	1	1	1	0.5	1	1
SUMA kolona	7.542	11.417	14.25	18	13.167	12.7	20.7	18	12	18.7	24	20

Figure 4. Saaty's scale with entered criteria ratio data.

According to Figure 4, the value of the matrix is entered in the upper part above the diagonal of the matrix, the diagonal of the matrix has the value 1, while the values below the diagonal in this case cannot be entered because they represent reciprocal values of their symmetries. The sum of the columns of the matrix is shown at the bottom of the table.

Normalizacija tabele, dijeljenje svih elemenata kolone sa sumom te kolone

	wgs	wu	wbčd	wir	wbčbi	wsbr	wno	wrsr	wbsd	wbu	wppč	ciklus	Prosječna vrijednost
wgs	0.133	0.263	0.281	0.444	0.152	0.157	0.097	0.167	0.083	0.053	0.042	0.05	0.16
wu	0.044	0.088	0.281	0.056	0.076	0.079	0.29	0.111	0.083	0.107	0.042	0.05	0.109
wbčd	0.033	0.022	0.07	0.056	0.228	0.157	0.048	0.111	0.083	0.214	0.083	0.3	0.117
wir	0.017	0.088	0.07	0.056	0.076	0.079	0.048	0.111	0.083	0.053	0.083	0.05	0.068
wbčbi	0.066	0.088	0.023	0.056	0.076	0.079	0.048	0.111	0.083	0.053	0.25	0.1	0.086
wsbr	0.066	0.088	0.035	0.056	0.076	0.079	0.242	0.056	0.083	0.053	0.042	0.1	0.081
wno	0.066	0.015	0.07	0.056	0.076	0.016	0.048	0.056	0.083	0.267	0.083	0.05	0.074
wrsr	0.044	0.044	0.035	0.028	0.038	0.079	0.048	0.056	0.083	0.053	0.042	0.05	0.05
wbsd	0.133	0.088	0.07	0.056	0.076	0.079	0.048	0.056	0.083	0.053	0.042	0.05	0.069
wbu	0.133	0.044	0.018	0.056	0.076	0.079	0.01	0.056	0.083	0.053	0.208	0.1	0.076
wppč	0.133	0.088	0.035	0.028	0.013	0.079	0.024	0.056	0.083	0.011	0.042	0.05	0.053
ciklus	0.133	0.088	0.012	0.056	0.038	0.039	0.048	0.056	0.083	0.027	0.042	0.05	0.056

Figure 5. Percentage normalization of the table.

Criteria normalization refers to dividing all elements of a column by the sum of that column, then an average value is calculated for each of the criteria, the average value is used to determine alternatives.

Težine (prioriteti) kriterijuma

Težine (prioriteti) kriterija izračunaju se kao prosječne vrijednosti elemenata redova normalizirane matrice. Svaki od elemenata matrice množimo sa noramaliziranom prosječnom vrijednošću za određeni kriterij.

Izracunaj vrijednosti alternativa

#	Ime	Prezime	Univerzitet	Fakultet	Godina studija 0.16	Ciklus 0.056	wu 0.109	wbčd 0.117	wir 0.068	wbčbi 0.086	wsbr 0.081	wno 0.074	wrsr 0.05	wbsd 0.069	wbu 0.076	wppč 0.053	Vrijednost alternativa
1	Ibrahim	Cehic	Bihac	Tehnicki	1.00	2.00	8.00	5.00	0.00	1.00	0.00	0.00	0.00	2.00	1.00	1700.00	92.68
2	Omer	Bijelic	Travnik	Rudarski	1.00	1.00	9.00	5.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	950.00	52.57
3	Azra	Selakovic	U Sarajevu	Pravni	3.00	1.00	9.50	7.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	2500.00	135.83
4	Amina	Kuduzovic	U Tuzli	Zdravstveni	4.00	1.00	9.00	2.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	550.00	31.44

Figure 6. Table with the calculated values of the alternative, after applying the weight of the criteria.

According to the table from Figure 6, for each criterion for each alternative, it is multiplied by the average value obtained by normalization. Values are calculated by pressing the "Calculate values of alternatives" button, and for the ranking of alternatives, the values obtained for all criteria are summed up.

4.1. Ranking page

The table with the ranking list of students displays the results of ranking students in the scholarship competition. In this table, students are arranged based on their overall point rating, which is calculated based on the defined criteria and the grades they received for those criteria. The students are ranked in descending order, meaning that the student with the highest rating is displayed first, followed by students in descending order of their rating.

Rangiranje kriterijima jednake važnosti | Rangiranje kriterijima sa težinskim vrijednosima

#	Ime	Prezime	Univerzitet	Fakultet	Godina studija	Ciklus	Zbir svih kolona u redu:
1	Amina	Kuduzovic	U Tuzli	Zdravstveni	4	1	6.02
2	Ibrahim	Cehic	Bihac	Tehnicki	1	2	5.09
3	Almir	Pasic	Konjic	Rudarski	2	2	5.00
4	Omer	Bijelic	Travnik	Rudarski	1	1	4.94
5	Azra	Selakovic	U Sarajevu	Pravni	3	1	4.75
6	Salih	Salkic	Mostar	Fit	3	1	4.54

Figure 7. Ranking list with equal importance criteria.

Rangiranje kriterijima jednake važnosti | Rangiranje kriterijima sa težinskim vrijednosima

#	Ime	Prezime	Univerzitet	Fakultet	Godina studija	Ciklus	Vrijednost alternativa težinski
1	Azra	Selakovic	U Sarajevu	Pravni	3	1	135.83
2	Salih	Salkic	Mostar	Fit	3	1	97.95
3	Ibrahim	Cehic	Bihac	Tehnicki	1	2	92.68
4	Omer	Bijelic	Travnik	Rudarski	1	1	52.57
5	Almir	Pasic	Konjic	Rudarski	2	2	47.75
6	Amina	Kuduzovic	U Tuzli	Zdravstveni	4	1	31.44

Figure 8. Ranking list with weight value criteria.

On the Ranking page, you can find two sections, one showing the ranking of students when all criteria are considered equally important, as shown in Figure 7. Ranking by equal importance criteria refers to the ranking procedure applied when all criteria used to evaluate alternatives are considered equally important. This means that each criterion is treated equally, and no criterion is given priority over others.

The table contains information about each student, such as their name, year of study, faculty, etc., as well as their overall point rating. Information about the student's rating according to individual

criteria can be viewed on the "Criteria Definition" page. This allows the competition organizers to see which criteria had the greatest impact on student ranking, which can help in making decisions regarding scholarship awards.

5. Conclusion

In this research, we focused on the application of the Analytic Hierarchy Process (AHP) as a multi-criteria decision-making method for student ranking and the implementation of a software solution to support this process. The aim was to investigate the effectiveness of the AHP method in the context of student ranking and evaluate the advantages that the software solution brings compared to traditional approaches. Overall, the application of the AHP method and the implementation of the software solution for student ranking represent valuable tools. They provide objectivity, transparency, and efficiency in the ranking process.

Through the use of multi-criteria decision-making, the application enables easier and faster evaluation of each candidate based on multiple criteria, allowing for a better understanding of the overall picture of each candidate. Additionally, it is possible to easily adjust the priorities of the criteria, providing flexibility in decision-making and allowing for adaptation of the ranking process to different needs and situations.

The applications can be found on Github:

- Application Angular: https://github.com/ibrahimcehic/AHP-rangiranje-studenata
- Backend: https://github.com/ibrahimcehic/AHP-rangiranje-backend

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Elliptic Curve Cryptography and its applications

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Abstract. In this paper we introduce Elliptic – curve cryptography (known as ECC) and its applications to mobile devices, online banking and payments. ECC is a public – key cryptography system based on algebraic properties of elliptic curves over finite fields. The security relies on the problem of Elliptic – curve discrete logarithm, which is hard to solve. It provides high security using much smaller key sizes than other public – key cryptography systems, such as RSA. In this paper we'll define Elliptic curves, public – key cryptography and discuss its real – world applications.

1. Introduction

People always wanted to secure their messages, so cryptography has been in use for centuries now. In first cryptosystems, messages were encoded and decoded by hand, using transposition or substitution. With development of technology more complex and secure cryptosystems were made and used. Modern cryptography relies on the idea that the key used for encryption can be public, but the key needed for decryption is private. One such cryptosystem relies on the theory of elliptic curves and the discrete logarithm problem. Theory of Elliptic curve cryptography can be found in [3], [1] and [7]. At the beginning of this paper we analyse elliptic curves and addition of two points on an elliptic curve. Later we analyse public – key cryptography with accent on Elliptic curve cryptography (ECC). In this section we explained Elliptic curve discrete logarithm problem, on which ECC relies. We also discuss encryption and decryption procedure, key exchange and message signing. In the last section we discuss some real – world applications of ECC, which can be found in [4], [5], [6], [8] and [9].

2. Elliptic curves

Let $\mathbb{K}$ be field with characteristic not equal to 2 or 3. Elliptic curve E over field $\mathbb{K}$ is set of solutions $(x, y), x, y \in \mathbb{K}$ of equation

$$y^2 = x^3 + ax + b, \tag{1}$$

where $a, b \in \mathbb{K}$ are constants that satisfy condition $4a^3 + 27b^2 \neq 0$, together with special point $\mathcal{O}$ which is called the point at infinity.

The condition $4a^3 + 27b^2 \neq 0$ ensures that the elliptic curve is smooth, so there are no points at which the curve has two or more distinct tangent lines. If $4a^3 + 27b^2 = 0$, then the corresponding curve is called singular cubic curve.

If the characteristics of field $\mathbb{K}$ is 2, then the elliptic curve over field $\mathbb{K}$ is set of solutions from one of the equations

$$y^2 + cy = x^3 + ax + b \quad \text{or} \quad y^2 + xy = x^3 + ax^2 + b,$$

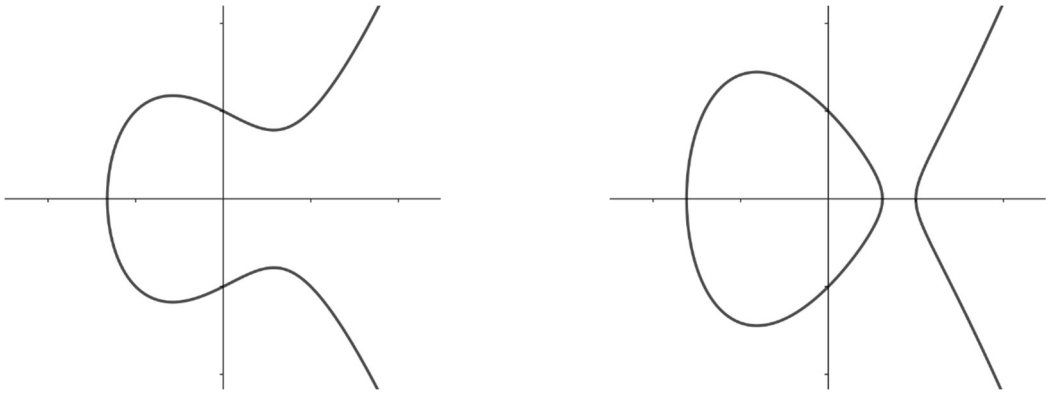
together with the point at infinity $\mathcal{O}$.

If the characteristics of field $\mathbb{K}$ is 3, then the elliptic curve over field $\mathbb{K}$ is set of solutions of the equation

$$y^2 = x^3 + ax^2 + bx + c, \quad a, b, c \in \mathbb{K}$$

together with the point at infinity $\mathcal{O}$.

In the following considerations we'll use elliptic curves defined with the equation (1). Graph of this elliptic curve is always symmetric with respect to the x – axis. Indeed, if the equation holds for point $P = (x, y)$, then it holds for point $-P = (x, -y)$ too. Let $\mathbb{K} = \mathbb{R}$ be field of real numbers. The elliptic curve (without point at infinity) is then a subset of a real plane. Depending on number of real zeros of polynomial $x^3 + ax + b$, elliptic curve can have one or two components. If the polynomial has one real zero, then the elliptic curve has one component, and if the polynomial has three real zeros, then the elliptic curve has two components (see figure 1).



(a) (b)

Figure 1. Example of elliptic curve with one component (a) and two components (b).

We can define addition on elliptic curves. Let E be an elliptic curve over field of real numbers $\mathbb{R}$ and $P = (x_1, y_1)$ and $Q = (x_2, y_2)$ two points on E. Considering the characteristic of field of real numbers is zero, elliptic curve E is defined with the equation (1). Suppose that P and Q are two distinct points and that $P \neq -Q$. To add points P and Q we need to draw a secant, line through the two points P and Q. This line intersects the elliptic curve in one more point $P * Q$. The point $P * Q$ is reflected across the x – axis to the point $P + Q$ (see figure 2).

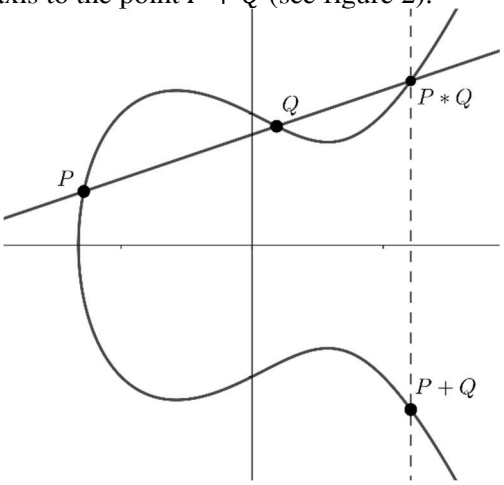


Figure 2. Geometric representation of the addition of two points P and Q on an elliptic curve when $P \neq \pm Q$.

If $P = Q$ we draw a tangent line to the elliptic curve E at a point P. This tangent line intersects the elliptic curve in one more point $P * P$. The point $P * P$ is reflected across the x – axis to the point $P + P = [2]P$.

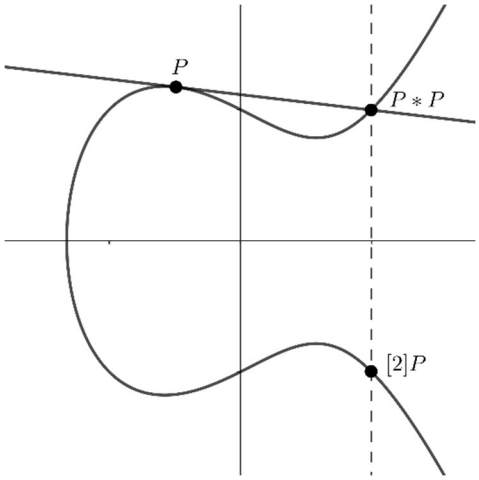


Figure 3. Geometric representation of the doubling point P on an elliptic curve.

If $P = -Q$, then the line through the two points is a vertical line which does not intersect the elliptic curve in another point. This is the reason why the point at infinity is added to the elliptic curve. Thus, the point at infinity $\mathcal{O}$ is neutral element for addition on elliptic curve. Inverse element of point $P = (x, y)$ is point $-P = (x, -y)$. This geometric description of elliptic curves can be used to write algebraic formulas for coordinates of the sum of two points on an elliptic curve.

If $P \neq \pm Q$, then $P + Q = (x_3, y_3)$ where

$$x_3 = \left(\frac{y_2 - y_1}{x_2 - x_1}\right)^2 - x_1 - x_2 \quad \text{and} \quad y_3 = \left(\frac{y_2 - y_1}{x_2 - x_1}\right) \cdot (x_1 - x_3) - y_1.$$

If $P = Q$, then $P + Q = (x_3, y_3)$ where

$$x_3 = \left(\frac{3x_1^2 + a}{2y_1}\right)^2 - x_1 - x_2 \quad \text{and} \quad y_3 = \left(\frac{3x_1^2 + a}{2y_1}\right) \cdot (x_1 - x_3) - y_1.$$

For usage in cryptography, most important elliptic curves are ones defined on finite fields $\mathbb{F}_q$ with q elements. In case of field $\mathbb{F}_p$, where p is prime, these fields are fields of all residues modulo p, called $\mathbb{Z}_p$. In this case, all operations in all algebraic formulas for coordinates of the sum are performed modulo p.

Order of elliptic curve ($\#E$) is number of points on that curve.

Theorem (Hasse) Let $E(\mathbb{F}_q)$ be an elliptic curve over finite field $\mathbb{F}_q$ with q elements. Then,

$$|\#E - (q + 1)| \leq 2\sqrt{q}.$$

The proof of Hasse theorem can be found in [10].

From Hasse theorem it's easy to conclude that there exists t for which $|t| \leq 2\sqrt{q}$ and $\#E = q + 1 - t$. That number is called the trace of Frobenius of elliptic curve E. Elliptic curve E defined over finite field $\mathbb{F}_q$ is called anomalous if its trace of Frobenius equals 1 ($\#E(\mathbb{F}_q) = q$). Elliptic curve E defined over finite field $\mathbb{F}_q$, $q = p^k$, where p is prime is called supersingular if p divides trace of Frobenius t of elliptic curve E.

Let P be a point on an elliptic curve E, then the order of point P is the smallest number k, for which $[k]P = \mathcal{O}$.

3. Public – key cryptography

Private – key cryptography or symmetric cryptography is a type of cryptosystem with one key, for encryption and decryption, which is kept secret. The most used private – key cryptosystem are Data Encryption Standard (DES) and Advanced Encryption Standard (AES), because they have an extremely fast encryption speed. However, they are unsuitable for use in public network, which has a larger number

of users. For a network with n users we need to generate $\frac{n(n-1)}{2}$ private keys. For larger n, it is hard to generate so many private keys and distribute them safely on a network. In this case, great solution is public – key cryptography which was first introduced by W Diffie and M Hellman in 1976.

Public – key cryptography or asymmetric cryptography is a type of cryptosystem involving two separate keys, one for encryption and other for decryption. The key for encryption is public and everyone can encrypt a message, resulting in ciphertext. However, only the ones who know the private key for decryption can decrypt the ciphertext to obtain the plaintext (the original message). Hence, for a public – key cryptography to work all we need is a function that is easy to compute in one direction, but difficult in the opposite direction without some extra information. Functions that have this characteristic are called trapdoor functions. Finding a good trapdoor function is crucial to making a public – key cryptographic system which is safe to use.

Public – key cryptosystems are much slower than modern private – key cryptosystems (like DES or AES). Modern cryptosystems use both private and public – key cryptosystems. Public – key cryptosystems are used to encrypt secret keys which are then used in communication with private – key cryptosystems.

Public – key cryptosystems are also used for digital signatures, electronic analogue of a handwritten signature. Alice (sender) uses her private key, together with message, to create a signature. Bob (receiver) can verify if the signature matches the message.

3.1. Elliptic curve cryptography

After introduction of RSA, cryptosystem which relies on difficulty of factoring a product of two large prime numbers, mathematicians started looking for other trapdoor functions. One of them is Elliptic Curve Discrete Logarithm problem (known as ECDLP). Cryptography based on that problem is called Elliptic curve cryptography (known as ECC). ECC provides highest strength per – bit security compared to other cryptosystems. Table 1 shows the key size comparison between RSA and ECC.

Table 1. Key size comparison for public key cryptosystems RSA and ECC

RSA key size (Bits)	ECC key size (Bits)	Key size ratio (RSA:ECC)
1024	163	6:1
3072	256	12:1
7680	384	20:1
15 360	512	30:1

We see that ECC needs less storage and less computing time, compared to other cryptosystems. This feature makes ECC compatible for mobile, handheld devices, smart – cards, which all have some limitation in terms of CPU and memory.

3.1.1. The Elliptic Curve Discrete Logarithm. Let E be an elliptic curve defined over a finite field $\mathbb{F}_q$ with q elements, and let $P \in E$ be a point of order n. If for scalar k, $0 \leq k \leq n-1$, there exists a point $Q \in E$, for which $Q = [k]P$, then the integer k is called the discrete logarithm of Q to the base P. For a given P and Q it is computationally impossible to find which k was used to compute point Q. This problem is known as Elliptic Curve Discrete Logarithm problem (ECDLP). However, not all elliptic curves are safe to use. For cryptographic purpose, the most common are elliptic curves over finite field $\mathbb{F}_p$ where p is a prime and finite field $\mathbb{F}_{2^m}$, where m is a positive integer.

3.1.2. Encryption and decryption. We'll mention one cryptosystem that uses elliptic curves and that is Menezes – Vanstone Elliptic Curve Cryptosystem (MVECC). Let E be an elliptic curve defined over

finite field $\mathbb{F}_p$, where $p > 3$ is a prime. With H we'll mark a cyclic subgroup of E generated with point $\alpha \in E$, and with a and k we'll name two constants from the field $\mathbb{F}_p$. Let β be a point on the curve E which satisfies the condition $\beta = [a]\alpha$. In MVECC, values E, α and β are public and a and k are kept secret. If Alice wants to send message $x = (x_1, x_2) \in \mathbb{F}_p \times \mathbb{F}_p$ (which could be the hash of a long message), then she'll compute (y_0, y_1, y_2), where $y_0 = [k]\alpha$, $y_1 = c_1 x_1 \ mod\ p$ and $y_2 = c_2\ x_2 \ mod\ p$, where $(c_1, c_2) = [k]\beta$. If Bob wants to decrypt the message he computes (x_1, x_2), using $x_1 = y_1 c_1^{-1} \ mod\ p$ and $x_2 = y_2 c_2^{-1} \ mod\ p$, where $[a]y_0 = (c_1, c_2)$.

3.1.3. Elliptic Curve Diffie – Hellman key exchange. Suppose that Alice and Bob want to exchange a key k. Key exchange can be done using elliptic curves. Let E be an elliptic curve defined over finite field $\mathbb{F}_p$, where $p > 3$ is a prime and α a point on an elliptic curve with order n. Alice selects an integer $n_a < n$ and computes $P_a = [n_a]\alpha$, while Bob selects an integer $n_b < n$ and then computes $P_b = [n_b]\alpha$. Points P_a and P_b are made public. Alice can generate the secret key by computing $k = [n_a]P_b$ and Bob computes $k = [n_b]P_a$. To find secret key k, an attacker would need to compute k knowing α and $[k]\alpha$ which is a problem hard to solve.

3.1.4. Elliptic Curve Digital Signature Algorithm. Digital signatures are used for authentication of participants and it can be done by using elliptic curves. Let E be an elliptic curve defined over finite field $\mathbb{F}_p$, where $p > 3$ is a prime. Suppose that Alice wants to sign a message m (which might be the hash of a long message) and that m, $0 \leq m < n$ is an integer, where n is the order of elliptic curve. If the previous relation does not hold then we should choose a larger p. Alice then chooses a random integer $1 \leq k < n$, $gcd(k, n) = 1$, computes point $[k]\alpha = (x, y)$, integer $r = x \ mod\ n$ and $s = k^{-1}(m - a \cdot x) \ mod\ n$. The signature is (r, s). When Alice sends that message to Bob, he is able to verify the signature. First, he computes $w = s^{-1} \ mod\ m$, $u_1 = mw \ mod\ n$ and $u_2 = rw \ mod\ n$. Next, he computes point $(x_0, y_0) = [u_1]\alpha + [u_2]\beta$ and integer $v = x_0 \ mod\ n$. If $v = r$ then the signature is valid.

4. Applications of Elliptic Curve Cryptography

Mobile devices and computers have many things in common. Today, we can use mobile phone as a computer. It provides operations such as accessing the internet, sending and receiving mails, communication via chat, audio and video, money transactions, online shopping, online reservations, etc. Security in all these operations is very important. These devices can use private key cryptosystems for encryption, but the problem is how to send the private key on a public infrastructure which is insecure. Public – key cryptosystems allow us to do it, but the problem is that public – key cryptosystems demand CPU and memory which is the limiting factor. Compared to other public – key cryptosystems, ECC has the highest strength – per – bit, and because of that ECC is a great choice. [4]

ECC is already used for voice encryption. Voice over Internet protocol (VoIP) communication system enables voice calls using internet and not regular (or analog) phone line. VoIP converts the analog speech signals to digital voice data, and then compress them to send them over internet. VoIP in packet – switch networks need to contain good speech quality and secure the communication, which often includes private information. Security protection is time-consuming process, so are cryptosystems with simple computation to encrypt voice data needed to use. AES is often used, which is private – key cryptosystem. Therefore, key – exchange is needed. For key – exchange ECC is used because of limitations. [9]

ECC is also commonly used for smart cards, which are used for authentication. They also contain information and provide access to systems and services. Smart cards can be used as debit or credit cards, personal identification cards, SIM cards, Passports, health insurance cards, etc. These applications demand security for all procedures made using them. However, smart cards are limited by constrained memory and limited computing power. Because of these limitations, ECC is commonly used. One of the most important security requirements on smart cards is mutual authentication. The system needs to

recognize the card and avoid using fake smart card to do some transactions. Also, it should not be possible for users to deny actions made by the use of service. [8]

5. Conclusion

In modern era, where mobile phones, tablets, smart cards and internet, are common, security in all of them is crucial. Many operations are made on the internet using mobile phones, like sending and receiving mails, communication via chat, audio and video, money transactions, online shopping, online reservation, etc. Wireless devices are becoming more dependent on security features for being able to secure all these operations. RSA was long in the use, but security requirements are changing. Now, cryptosystems need to be faster and more secure so that they are compatible with wireless devices which have less memory, CPU cycles, etc. We see that elliptic curve found its use in modern cryptography because of the difficulty of solving ECDLP.

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Managing servlet variables in Java web applications built without and with the Spring framework

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Abstract. There are problems in web applications that are very difficult to test and find out how these problems should be overcome. This paper presents a problem that can occur with class-level variables in Java web applications. The problem with global variables at the level of a servlet that acts as a front controller in a web application is demonstrated through specific examples, and then specific solutions are presented to overcome this problem. As part of one of the solutions to the mentioned problem, helper classes were introduced, and another solution was presented with the help of the Spring framework.

1. Introduction

We can create a website with static HTML pages, but when we want the information to be dynamic, we need a web application. Java web applications represent dynamic web pages. Java for web applications provides support through servlets and JSPs (Java Server Pages).

Servlets are the central processing unit of a Java web application and are responsible for most of the processing required by a web application. Specifically, a servlet is a Java class that implements the javax.servlet.Servlet interface [1]. The servlet interface defines the methods that all servlets must implement. This interface, along with other methods, defines key lifecycle methods such as init(), service(), and destroy() to initialize a servlet, to request a service, and to remove a servlet from the server, respectively.

Controllers can be written as JSPs or as servlets. Since the controller will not contain any HTML, it is better to write it as a servlet. JSPs are designed to have HTML with little Java code. Whenever a JSP contains mostly Java code with very little or no HTML, then it should be written from the start as a servlet, not as a JSP [2].

Ever since its appearance of the object-oriented approach to program development, there has been a motivation for Model-View-Controller (MVC) application development. Before the introduction of the MVC model, the browser directly accessed JSP pages (view). In other words, JSP pages handled user requests directly. This kind of architecture is called Model-1 and represents decentralized control [2].

The Model-2 architecture for designing JSP pages is actually an MVC approach applied to web applications. MVC originated in Smalltalk and is now well accepted by the Java community [3]. Figure 1 shows the Model-2 architecture (MVC). In Model-2, the front controller handles the user request instead of a specific JSP page. The front controller is implemented as a servlet.

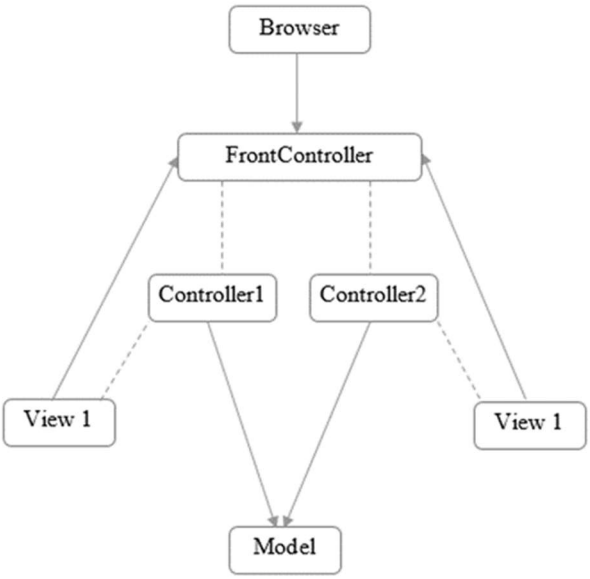

Figure 1. Model-2 architecture with front controller [4].

MVC follows the most common layering approach. Layering is a service that separates our code into functions in different classes [5]. This approach is easily recognizable and the most widely accepted. The main advantage of this approach is the possibility of code reuse [6].

2. Servlet variables

In object-oriented design, class variables are powerful tools [4]. By using class variables, the number of parameters that must be passed to methods can be reduced. Class variables also allow data encapsulation: access to class-level variables can be restricted using certain methods. However, using variables at the servlet level is dangerous and can lead to problems. A servlet can contain two types of variables:

- Servlet variables - variables at the servlet level and
- Local variables - variables defined within a specific method in the servlet.

When a user visits a web page that has a form, he fills in the data in the form, after which he clicks the submit button on the form. If multiple requests are made at the same time, then the server processes each set of data independently. Data from one request will not be mixed with data from another request. The server ensures that data is processed independently using threads. A thread is like a separate process on a computer. Each thread works independently of all other threads. Each request to the web application creates a new thread on the server and executes the same set of instructions. However, servlet variables can be accessed by all threads. If two threads try to save a value to a servlet variable, only the value written by the last thread will be stored.

The previously described situation presents a problem with servlet variables, making them dangerous to use in a servlet. We can think of servlet variables as being more like static variables in a simple Java program.

3. Local versus servlet variables

If two users on different machines access the servlet at the same time, then each of them will have their own doGet method running in their own thread. Variables that are local to the doGet method are private variables that cannot be accessed from another thread. However, as mentioned earlier, servlet variables are shared by all threads.

Let's consider the controller in Figure 2 that owns the variable nameUser as a servlet variable. Let's imagine that we have two users named Emir and Amar who, in a very short period of time, send their requests to the servlet, that is, the front controller, through a form in the browser, and pass the value of the field UserName to it. as a GET request. Figure 2 shows the code of the servlet that receives the specified requests.

```
. . . . . .
String useName ="";
public void doGet(HttpServletRequest request, HttpServletResponse response) {
   String returnMessage="";
   userName = request.getParameter("UserName");

   // working with the database

   returnMessage = "Thank you " + userName;

/* sending a return message to the user via the response object
    with the content from the returnMessage variable */
   }
. . . . . .
```

Figure 2. Servlet code that accepts concurrent requests from two users.

In the code from Figure 2, we have a defined servlet variable userName that is created and initialized once upon receiving the first request and is shared with all other incoming requests. Figure 3 shows a possible scenario of the arrival of two requests in a very short time interval according to the servlet whose code is shown in Figure 2.

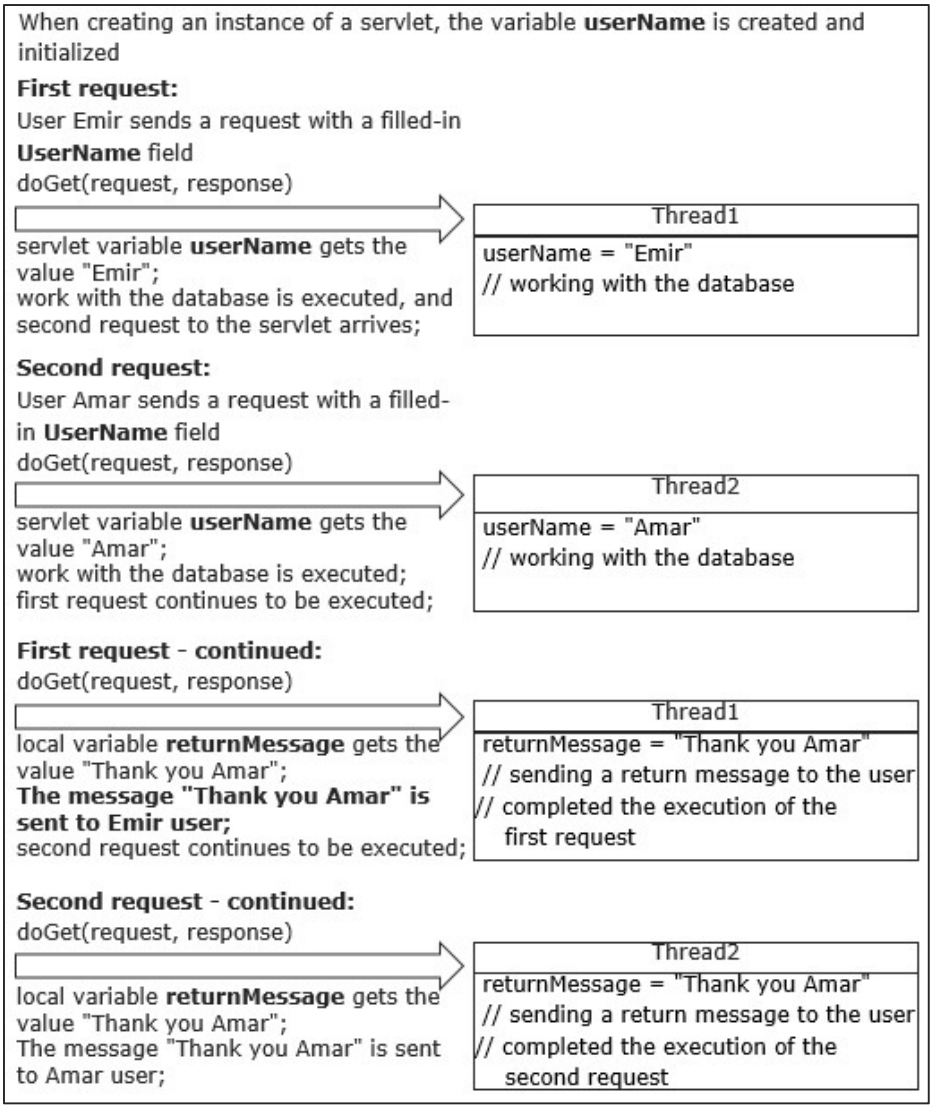

Figure 3. How a servlet processes two requests whose execution is done simultaneously.

A servlet is loaded and executed by the servlet engine when the servlet is invoked for the first time. After that, the servlet sits in memory and processes requests from the browser. Each request is processed in a different thread. This means that servlet variables are created and initialized when the servlet is first loaded and executed. Each new request will share the servlet variables.
Simultaneous execution of two requests with the scenario shown in Figure 3 showed that the user Emir, after entering the name of his name "Emir" in the form in the browser, received a return message "Thank you Amar", with the name of another user. This is caused by improper use of servlet variables that are shared by all requests coming to that servlet.

Servlet variables are useful and it would be nice to be able to use them in the controller. As shown, controllers communicate with the browser via request and response objects. Any helper method that needs to know information about the request or that needs to add information to the response should pass these objects as parameters. Therefore, these two objects should be placed in variables, so that they can be accessed by any method in the controller.

4. Helper classes

The problem with class-level variables is limited only to classes that inherit from the HttpServlet class. However, servlet variables can be used in any class that does not inherit from the HttpServlet class. Therefore, a helper class will be created that will store request and response objects as variables of that helper class. This helper class can also have helper methods. These helper methods will have direct access to the request and response objects. And the doGet method can be added to the helper class, so the front controller only needs to call the doGet method from the helper class.

The helper class should also have a reference to the servlet it helps. Although the helper class will do all the work, the servlet that is the front controller still receives the initial request from the servlet engine. Sometimes it will be necessary to retrieve information about the servlet when processing the request. An additional variable for the servlet class will be added to the helper class.

Two types of variables can be added to a helper class. Some of the variables that are added are not specific to the controller, but are common to all controllers. For example, request, response, and servlet objects have the same structure for all controllers. On the other hand, some variables are unique to the controller, such as the bean that encapsulates the data from the request.

Those variables that are common to all controllers can be placed in the base class, while those that are specific to the controller will be placed in a class that inherits (extends) the base class. The base class will be called BaseHelper and the extended class is usually called ControllerHelper. Figure 4 shows the relationship between the two classes, all their variables as well as helper methods.

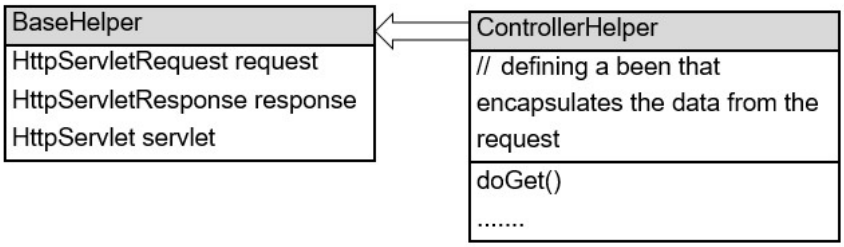

Figure 4. ControllerHelper inherits BaseHelper class.

4.1. Creating a base helper class

A base helper class named BaseHelper will contain variables that are common to all controllers, such as request, response, and servlet objects. These objects have the same structure regardless of the controller that uses them. Helper methods are added to the class to facilitate access to those variables.

The method in the base helper class must set request, response and servlet objects. They should be set as soon as the base helper class is created. We will place them in the constructor for the BaseHelper class. BaseHelper will not have a default constructor, it will only have a constructor that has parameters for request, response and servlet objects. Whenever a new BaseHelper object is created, the current request, response, and servlet objects will be passed to the constructor. Since these three variables will

not change during the lifetime of the controller, they are marked as protected. Figure 5 shows the code that creates the BaseHelper class.

```
import javax.servlet.http.HttpServlet;
import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;

public class BaseHelper {

   protected HttpServletRequest request;
   protected HttpServletResponse response;
   protected HttpServlet servlet;

   public BaseHelper(HttpServlet servlet,
                     HttpServletRequest request,
                     HttpServletResponse response) {
      this.servlet = servlet;
      this.request = request;
      this.response = response;
   }

}
```

Figure 5. Code of the helper class BaseHelper.

4.2. Creating a helper controller

The main motivation for using a helper controller is the ability to use controller variables. There are two types of controller variables:

- those created in the helper controller and
- those created in the base helper class.

All the work for the front controller will be done by the controller helper (ControllerHelper). The front controller (servlet) will still receive requests from the browser (browser), but will then delegate the work to the back controller. For this reason, the helper controller will have a doGet method that does all the work that was previously done by the front controller. The front controller will just create the helper controller and call its doGet method.

A helper controller can contain variables that are specific to the current controller, such as a bean that contains request data. A bean can have a different structure for each controller, since each bean will contain different properties that contain the data that the user enters. For this reason, it cannot be placed in the base helper class BaseHelper. Whenever the variable type can be different for each controller, it will be added to the helper controller.

The helper controller must initialize all of its variables. Since the helper controller will inherit from the base helper class BaseHelper, it must initialize the request, response, and servlet variables stored in the base helper class. The helper controller constructor will have parameters for the request, response, and servlet objects. The constructor must call the constructor of the base helper class with these parameters. The call to super (servlet, request, response) must be the first statement in the helper controller's constructor. A call to the base constructor will set the values of the request and response objects in the base helper class shown in Figure 6.

Figure 7 shows the basic servlet code of the front controller Controller, which is still the only one that receives requests from the user and through its doGet method forwards the request to the doGet method of the helper controller ControllerHelper) after its instance is first created.

```
public class ControllerHelper extends BaseHelper {
 . . . . . .
    public ControllerHelper(HttpServlet servlet,
    HttpServletRequest request,
    HttpServletResponse response)  {
            super(servlet, request, response);
            . . . . . .
    }
    public void doGet()
. . . . . .
}
```

Figure 6. Code of the helper class ControllerHelper.

```
public class Controller extends HttpServlet {

   public void doGet(HttpServletRequest request,
                     HttpServletResponse response)
   throws ServletException, IOException {
      ControllerHelper helper =
         new ControllerHelper(this, request, response);
      helper.doGet();
   }
}
```

Figure 7. Code of the front (servlet) controller Controller.

In the previously described way, the unwanted sharing of servlet variables that are created during the creation of the servlet instance, i.e. the front controller, was completely avoided. So if we go back to the scenario shown in Figure 3 and implement it with a servlet as a front controller with helper controllers then it will not be possible for the user Emir to receive a "Thank you Amar" message back, because both requests will be created in threads that are processed by their own instances request, response and servlet objects.

5. Spring retrieving request variables

The Spring framework provides a comprehensive programming and configuration model for modern business web applications based on the Java programming language [7]. Spring implements inversion of control [IoC]. The concept of IoC is to loosen the relationship between classes [3]. Instead of initializing a specific local variable in a class with another specific class, use an interface to indicate the type of class that is needed. Spring manages the creation of a concrete class for a defined interface and injects it into the class where the variable is defined through the interface at the moment when its instance is created.

Spring manages request and response variables via IoC, and does not expose them to the developer as servlet variables. Behind the scenes, Spring creates properties for these variables, but they can only be accessed as local variables in the method. If a method wants to use one of these Spring-managed variables, it adds a parameter to the method and Spring will automatically bind it. If a method does not require a variable, then that variable cannot be accessed.

Figure 8 shows that such methods can have instances of shared servlet variables automatically linked in the method by including a parameter for them in that method's definition.

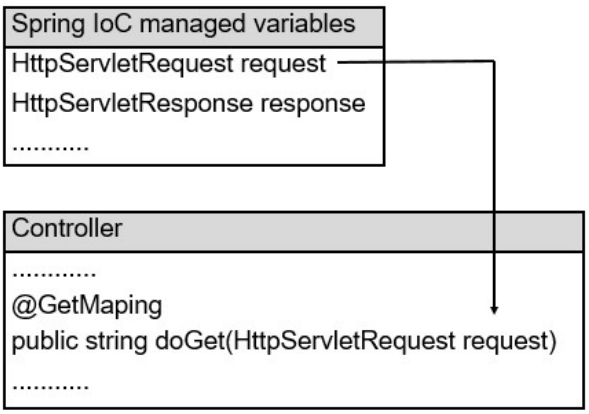

Figure 8. A variable for an HTTP request can be automatically bound in a Controller method.

Any method in a Spring controller can handle HTTP requests if the method is annotated with the GetMapping annotation. The doGet method handler will add the HttpServletRequest parameter to get

access to the request object. Spring IoC will automatically bind the request object to the parameter of the doGet method shown in Figure 9.

```
@GetMapping
public String doGet(HttpServletRequest request,
                    HttpServletResponse response) {
    .....
    .....
}
```

Figure 9. The code of the doGet method inside the Spring Controller (Servlet) manager.

Other annotations can be used in addition to the GetMapping annotation and are set as needed.

6. Conclusions

One of the disadvantages of servlets is the problem with using variables at the servlet class level. This limitation goes against one of the core concepts of object-oriented design. In this paper, it is discussed in detail and two solutions to this problem are offered, such as avoiding the use of servlet variables or via Spring's downloading of these variables. In the first approach, a helper class is introduced that can use class-level variables to simplify controller tasks. A base helper class is introduced for variables that are the same for all front controllers that accept user requests. The variables added to this class are for the request, response, and servlet objects. In most situations, class-level variables should be avoided in servlets. Spring indicates that methods can have instances of shared servlet variables automatically linked in the method by including a parameter for them in the method definition as a local variable.

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Comparison of Some Primality Tests

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Abstract. The most common implementation of public-key cryptography is ensuring data protection. Modern cryptography algorithms often use prime numbers and large composite numbers whose factorization is very difficult. The security of many of these algorithms therefore depends on the difficulty of factorization of the public keys. Primality testing algorithms are used to determine whether a particular number is prime or composite. These tests are essential to modern encryption algorithms. There are many different primality tests and choosing the correct one for a given application can be challenging. In this paper we present and compare some primality tests. Open-source computer algebra system PARI/GP is used to carry out the primality tests.

1. Introduction

Computational number theory is a young branch of number theory. One of its main goals is using theories and techniques from computing science to solve problems in various branches of number theory such as elementary number theory, algebraic number theory, analytic number theory, combinatorial number theory, probabilistic number theory, arithmetic algebraic geometry, etc. However, the main driving force in computational number theory is cryptography (particulary public-key cryptography) as the security of many of the cryptographic schemes and protocols relles on the intractability of same computational number-theoretic problems. For example, the most famous and widely used public-key cryptosystem RSA is based on the simple number-theoretic fact that it is easy to find a large prime number, but factoring a large composite number may be difficult.

A primality test is an algorithm for determining whether a given number is prime. Primality tests come in two varieties: deterministic and probabilistic. A primality test is deterministic if it outputs "true" when the given number is prime and "false" when it is composite with probability *1*. Otherwise, the primality test is probabilistic. A probabilistic primality test is often called a pseudoprimality test. Probabilistic tests may, with some small probability, identify a composite number as a prime, but not vice-versa.

Examples of deterministic tests include the Lucas-Lehmer test (can only be applied for Mersenne numbers), Pepin's test (can only be applied for Fermat numbers), APR test (Adleman-Pomerance-Rumely) and ECPP (Elliptic Curve Primality Proving). The most elementary approach to primality proving is trial division: attempt to divide a given number N by every integer $1 < p \leq \sqrt{N}$. If no such p divides N, then N is prime. This test is impractical for large values of N, but it serves as a base case for more sophisticated recursive methods. For very small numbers we can use the Sieve of Eratosthenes.

Until recently, no primality test that was general, deterministic, unconditional and polynomial-time was known. In 2002, Agrawal, Kayal and Saxena [1] published a deterministic primality-proving algorithm. This algorithm was the first one that was able to determine in polynomial time, whether a given number is prime or composite, without relying on mathematical conjectures, such as the

generalized Riemann hypothesis. This test is now known as the AKS primality test, Cyclotomic AKS test or Agrawal-Kayal-Saxena primality test.

Examples of probabilistic tests include the Fermat, Solovay-Strassen, Miller-Rabin, Lucas and Baillie-PSW tests. The Fermat primality test is based on Fermat's Little Theorem. The Solovay-Strassen test is based on Euler's Criterion. The Miller-Rabin test is based upon the fact that there are non-trivial roots of unity modulo a prime. The Lucas test makes use of Lucas sequences. The Baillie-PSW (Pomerance, Selfridge, Wagstaff) test is a combination of the Miller-Rabin test for base *2* and the Lucas test.

2. Some definitions and statements

In this section, we present certain definitions and statements (without proofs) which are used in the later sections.

Definition 1. A *prime number* (or a *prime*) is a positive integer greater than *1* whose only positive factors are *1* and itself. A positive integer greater than *1* that is not prime is called a *composite number*.

Remark 1. Number *1* is neither prime nor composite. Number *2* is the smallest prime. It also the only even prime number.

Theorem 1. (Fundamental Theorem of Arithmetic) Every positive integer *n* greater than *1* can be written uniquely as the product

$$n = {p_1}^{\alpha_1} \cdot {p_2}^{\alpha_2} \cdots {p_k}^{\alpha_k},$$

where $p_1, p_2, \ldots, p_k$ are distinct primes and $\alpha_1, \alpha_2, \ldots, \alpha_k$ are positive integers.

Theorem 2. (Prime Number Theorem) Let *x* be a positive real number. For large values of *x*, $\pi(x)$ is approximately equal to $x/\ln x$, where $\pi(x)$ denotes the number of primes less than or equal to *x*.

Definition 2. Let *a* and *b* be integers and *n* a positive integer. We say that *a* is *congruent* to *b* modulo *n*, denoted by $a \equiv b \ (mod\ n)$, if *n* is a divisor of $a - b$.

Theorem 3. (Fermat's Little Theorem) Let *a* be a positive integer and *p* a prime. If $\gcd(a, n) = 1$, then

$$a^{p-1} \equiv 1 \ (mod\ p).$$

Theorem 4. (Converse of Fermat's Little Theorem) Let *n* be a positive odd integer. If $\gcd(a, n) = 1$ and

$$a^{n-1} \not\equiv 1 \ (mod\ n),$$

then *n* is composite.

Definition 3. Let *a* be any integer and *n* a positive integer, such that $\gcd(a, n) = 1$. Then *a* is called a *quadratic residue* modulo *n* if the congruence

$$x^2 \equiv a \ (mod\ n)$$

is solvable. Otherwise, it is called a *quadratic nonresidue* modulo *n*.

Theorem 5. (Euler's Criterion) Let *p* be an odd prime and *a* a positive integer with $\gcd(a,p)=1$. Then *a* is a quadratic residue modulo *p* if and only if

$$a^{(p-1)/2} \equiv 1 \ (mod\ p).$$

Definition 4. Let *p* be an odd prime and *a* an integer, such that $\gcd(a,p)=1$. The *Legendre symbol* $\left(\frac{a}{p}\right)$ is defined as

$$\left(\frac{a}{p}\right) = \begin{cases} 0, & if\ p \text{ divides } a, \\ 1, & if\ a\ is\ a\ quadratic\ residue\ modulo\ p, \\ -1, & if\ a\ is\ a\ quadratic\ nonresidue\ modulo\ p. \end{cases}$$

Definition 5. Let *a* be an integer and $n>1$ an odd integer. If $n = {p_1}^{\alpha_1} \cdot {p_2}^{\alpha_2} \cdots {p_k}^{\alpha_k}$, then the *Jacobi symbol* $\left(\frac{a}{n}\right)$ is defined as

$$\left(\frac{a}{n}\right) = \left(\frac{a}{p_1}\right)^{\alpha_1} \cdot \left(\frac{a}{p_2}\right)^{\alpha_2} \cdots \left(\frac{a}{p_k}\right)^{\alpha_k},$$

where $\left(\frac{a}{p_i}\right)$ for $i = 1, 2, \ldots, k$, is the Legendre symbol.

Definition 6. Let *n* be an odd composite number and *b* a positive integer, such that $\gcd(b,n)=1$. Then *n* is called a *Fermat pseudoprime* to base *b* (denoted by $psp(b)$) if

$$b^{n-1} \equiv 1 \ (mod\ n).$$

Definition 7. A composite number *n* that satisfies

$$b^{n-1} \equiv 1 \ (mod\ n)$$

for every positive integer *b* such that $\gcd(b,n)=1$, is called a *Carmichael number*.

Definition 8. Let *n* be an odd composite number and *b* a positive integer such that $\gcd(b,n)=1$. If *n* and *b* satisfy the congruence

$$\left(\frac{b}{n}\right) \equiv b^{(n-1)/2} \ (mod\ n),$$

then *n* is called an *Euler pseudoprime* to base *b* (denoted by $epsp(b)$).

Theorem 6. [2] Every Euler pseudoprime to some base *b* is also a Fermat pseudoprime to the same base.

Remark 2. The converse of Theorem 6 is not true. For example, *91* is $psp(3)$, but not $epsp(3)$.

Definition 9. Let *n* be an odd composite number with $n-1 = t \cdot 2^s$, where *t* is a positive odd integer and *b* a positive integer, such that $\gcd(b,n)=1$. If *n* and *b* satisfy either

$$b^t \equiv 1 \ (mod\ n)$$

or

$$b^{t \cdot 2^r} \equiv -1 \ (mod\ n)$$

for some $0 \leq r < s$, then *n* is called a *strong pseudoprime* to base *b* (denoted by $spsp(b)$).

Theorem 7. [2] Every strong pseudoprime to some base *b* is also an Euler pseudoprime to the same base.

Remark 3. The converse of Theorem 7 is false. For example, *1105* is $epsp(2)$, but not $spsp(2)$.

3. Coding the primality tests

In this section, we present three primality tests: Fermat, Solovay-Strassen and Miller-Rabin test. Open-source computer algebra system PARI/GP [3] is used to carry out the primality tests.

A positive integer *w*, where $w < n$, is a witness to the compositeness of *n* if it proves that *n* is composite. If we denote the set of witnesses to the compositeness of *n* by $W(n)$, then the elements of its complement $L(n) = \mathbb{Z}_n \setminus W(n)$ are called liars, where $\mathbb{Z}_n = \{0, 1, 2, \dots, n-1\}$.

A probabilistic primality test utilizes properties of the sets $W(n)$ in the following manner [4]. suppose that *n* is a positive integer whose primality is to be determined. An integer $b \in \mathbb{Z}_n$ is chosen at random, and it is checked if $b \in W(n)$. The test outputs "composite" if $b \in W(n)$, and outputs "prime" if $b \notin W(n)$. If indeed $b \in W(n)$, then *n* is said to "fail the primality test for the base *b*". In this case, *n* is surely composite. If $b \notin W(n)$, then *n* is said to "pass the primality test for the base *b*". In this case, no conclusion with absolute certainty can be drawn about the primality of *n*, and the declaration "prime" may be incorrect. Any single execution of this test which declares "composite" establishes this with certainty. On the other hand, successive independent runs of the test that all of which return the answer "prime", allow the confidence that the input is indeed prime to be increased to whatever level is desired – the cumulative probability of error is multiplicative over independent trials.

In all three presented tests, inputs are *n*, *b* and *k*, where *n* is an odd composite number, whose primality is to be determined; *b* is a positive integer called base, such that $\gcd(b, n) = 1$; *k* is a positive integer which denotes the number of independent runs of the test.

3.1. Fermat Test

This test is based on the Fermat's Little Theorem.

Algorithm 1 (Fermat Test)

if $b^{n-1} \equiv 1 \ (mod\ n)$ ***then return***(prime)
else return(composite)

If Algorithm 1 returns "composite", then *n* is certainly composite. On the other hand, if the algorithm returns "prime", then no proof is provided that *n* is indeed prime. Nonetheless, since pseudoprimes for a given base *b* are known to be rare, Fermat test provides a correct answer for most inputs. The probability that Fermat test [2] declares a composite *n* to be "prime" is less than $(1/2)^k$.

Above discussion is quite distinct from providing a correct answer most of the time (e.g. if run with different bases) on every input. In fact, it does not do the latter because there are (even rarer) composite numbers (Carmichael numbers) that are pseudoprimes to every base *b* for which $\gcd(b, n) = 1$. There are infinitely many Carmichael numbers.

Modular exponentiation can be performed efficiently with the repeated square-and-multiply algorithm [4], which is crucial for many cryptographic protocols. It is efficient to compute, even for very large integers.

Let *a*, *k* and *n* be positive integers, such that $a, k < n$. Let $k = \sum_{i=o}^{v} k_i \cdot 2^i$ be the binary representation of *k*. Following algorithm computes $a^k \ mod\ m$.

Algorithm 2 (Repeated square-and-multiply algorithm for modular exponentiation)

$b = 1$

$A = a$
if $k_0 = 1$ ***then*** $b = a$
for i ***from*** 1 ***to*** v ***do***
    $A = A^2 \ mod \ m$
    if $k_i = 1$ ***then*** $b = A \cdot b \ mod \ m$
return*(b)*

3.2. Solovay-Strassen test
Solovay-Strassen test is based on Euler's Criterion. This test was proposed [5] to check whether a given number *n* is composite or probable prime. It was popular at the beginning of public-key cryptography use. There is no longer any reason to use this test, because an alternative is available (the Miller-Rabin test) which is both more efficient and always at least correct.

Algorithm 3 (Solovay-Strassen Test)

$r = b^{(n-1)/2} \ mod \ m$
if $r \neq 1$ ***or*** $r \neq n - 1$ ***then return***(composite)
$z = \left(\frac{b}{n}\right)$ (Jacobi symbol)
if $r \equiv z$ ***then return***(prime)
    else return(composite)

If Algorithm 3 returns "composite", then *n* is certainly composite because prime numbers do not fail Euler's Criterion. Equivalently, if *n* is actually prime, then the algorithm always returns "prime". On the other hand, if *n* is actually composite, then since the bases *b* are chosen independently during each iteration, this can be used to deduce the probability of the algorithm erroneously returning "prime". The probability that Solovay-Strassen test [4, 7] declares a composite *n* to be "prime" is less than $(1/2)^k$. There are no analogues of Carmichael numbers for Solovay-Strassen test, i.e. there are no positive integers which are $epsp(b)$ for every base b.

3.3. Miller-Rabin test
The first version [8] of the so-called Miller-Rabin test, also known as the strong pseudoprime test, was deterministic, assuming the correctness of extended Riemann hyphotesis (ERH). Second version [10] was a probabilistic algorithm. The test detects the primality of a number by testing two criteria. In the first part, the Fermat test is run. If the input number *n* is declared as a composite, then it is correct answer and the main test already terminates. Otherwise, the second part of the test tries to detect a non-trivial square root of *1* modulo *n*. If there is one, then *n* is composite number. Otherwise, *n* is probable prime. There are no analogues of Carmichael numbers for this test. Every Carmichael number which can be caught, will be declared as composite.

Algorithm 4 (Miller-Rabin Test)

write $n - 1 = t \cdot 2^s$ (t is odd)
$y = b^t \ mod \ n$
if $r = 1$ ***or*** $r = n - 1$ ***then return***(prime)
    else do
        $r = 1$
        while $r < s$ ***and*** $y \neq n - 1$ ***do***
            $y = y^2 \ mod \ n$
            if $y = 1$ ***then return***(composite)
            $r = r + 1$
        if $y = n - 1$ ***then return***(prime)
            else return(composite)

Similar to Algorithm 3, if Algorithm 4 returns "composite", then *n* is certainly composite, and if *n* is actually prime, then the algorithm always returns "prime". On the other hand, if *n* is actually composite, then since the bases b are chosen independently during each iteration, this can be used to deduce the probability of the algorithm erroneously declaring "prime". The probability that Miller-Rabin test [4, 7] declares a composite *n* to be "prime" is less than $(1/4)^k$.

4. Implementation and experimental evaluation

We used built-in functions of PARI/GP to carry out some technical tasks, such as finding the exact number of primes that are less than a given integer. Running through all the source codes given in the earlier section, we managed to make lists of prime numbers and differentiate pseudoprimes. We obtained the number of pseudoprimes (Fermat (*psp*), Euler (*epsp*), strong (*spsp*)) that are less than or equal to 10^k $(k = 3,4,5,6,7)$ with base $2 \leq b \leq 10$. We took $k \geq 3$, because there are almost no pseudoprimes that are less than 100. In Table 1, we wrote the percentage of different pseudoprimes in mentioned intervals. The smaller the percentage, the better the test is.

Table 1. Percentage of $psp(b)$, $epsp(b)$ and $spsp(b)$ in interval $[1, 10^k]$ for $k = 3, 4, 5, 6, 7$.

b	Pseudo	10^3	10^4	10^5	10^6	10^7
2	*psp*	0,90	0,58	0,19	0,06	0,02
	epsp	0,30	0,32	0,09	0,03	0,01
	spsp	0,00	0,13	0,04	0,01	0,004
3	*psp*	3,01	1,05	0,32	0,10	0,003
	epsp	1,20	0,43	0,16	0,05	0,001
	spsp	1,20	0,29	0,10	0,03	0,001
4	*psp*	2,71	1,25	0,38	0,11	0,03
	epsp	0,90	0,58	0,19	0,06	0,02
	spsp	0,30	0,27	0,08	0,02	0,01
5	*psp*	1,29	0,61	0,22	0,07	0,02
	epsp	0,43	0,29	0,09	0,03	0,01
	spsp	0,43	0,18	0,05	0,02	0,01
6	*psp*	3,01	1,28	0,44	0,12	0,003
	epsp	1,20	0,48	0,19	0,05	0,002
	spsp	1,20	0,38	0,13	0,03	0,001
7	*psp*	1,91	0,49	0,21	0,07	0,02
	epsp	1,15	0,26	0,09	0,03	0,01
	spsp	1,15	0,20	0,06	0,02	0,005
8	*psp*	6,02	1,86	0,54	0,16	0,05
	epsp	2,41	0,82	0,27	0,08	0,02
	spsp	1,20	0,34	0,11	0,03	0,01
9	*psp*	4,82	1,47	0,50	0,14	0,04
	epsp	3,01	1,05	0,32	0,10	0,03
	spsp	2,41	0,71	0,23	0,06	0,02
10	*psp*	4,72	1,12	0,30	0,08	0,02
	epsp	1,72	0,32	0,10	0,03	0,01
	spsp	0,86	0,25	0,05	0,02	0,005

It is seen from the output that there are less strong pseudoprimes than Euler and Fermat pseudoprimes. Also, there are less Euler pseudoprimes than Fermat pseudoprimes. Miller-Rabin test is better in testing primality than the other two primality tests, since they often fail to correctly identify an integer *n*. By the obtained output, Fermat test and Solovay-Strassen test have more pseudoprimes than

Miller-Rabin test. From the test output list, we have deduced that for testing prime numbers, Fermat test has the biggest number of errors, while Miller-Rabin test has the smallest.

We have also determined the number of strong pseudoprimes using the built-in PARI/GP function $ispseudoprime(x,1)$ for each specified range. This function uses Miller-Rabin test with randomly chosen base b. We repeated the test 10 times for each specified range and we took the average value $\overline{spsp(random)}$ for each range. In Table 2, we compared those values with values $\overline{spsp(b2-b10)}$, where $\overline{spsp(b2-b10)}$ denotes the average number of strong pseudoprimes produced with Algorithm 4 in each mentioned range with bases $b = 2, 3, \dots, 10$.

Table 2. Number of $\overline{spsp(b2-b10)}$ vs $\overline{spsp(random)}$.

Range	$\overline{spsp(b2-b10)}$	$\overline{spsp(random)}$
10^3	2,1	6,9
10^4	8,3	15,0
10^5	27,9	40,1
10^6	85,4	99,3
10^7	249,7	225,1

5. Conclusion

A probabilistic (randomized) algorithm (test) is an algorithm that employs a certain degree of randomness as a part of its logic or procedure. One class of probabilistic tests are Monte Carlo tests. Monte Carlo is a probabilistic (randomized) test whose output may be incorrect with a certain (typically small) probability. All three described primality tests are Monte Carlo tests. If the number under question is found to be prime, then the error percentage (which depends on the certainty value), should be considered and this number is called a probable prime. Whereas, if it is found to be composite, then the finding is said to be 100% accurate.

Fermat test has weaknesses because there exist Carmichael numbers. Both the Solovay-Strassen and Miller-Rabin tests are efficient probabilistic primality tests. Miller-Rabin test has the least number of pseudoprimes, compared to the other two tests, and the Solovay-Strassen test has less pseudoprimes than the Fermat test. Therefore, this makes the Miller-Rabin test superior to Fermat and Solovay-Strassen test (which is better than Fermat test).

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Comparison of Single Page Application frameworks

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Abstract. This paper presents a comparison of Single Page Application frameworks based on the JavaScript programming language. According to the number of downloads, React is the first choice, and it is also rated the best framework according to the "GitHub stars" evaluation. However, Svelte is the most popular framework according to the "Stackoverflow" survey. Therefore, choosing a framework can be difficult, but there is no best framework, only the most suitable choice for the job. This paper compares three frameworks, React.js, Angular, and Vue.js. The comparison is based on available data from various platforms that contain statistical data, and performance is measured using the Developer Tool, which is part of the Google Chrome browser.

1. Introduction

At the beginning of development, JavaScript enabled small functionalities for previously static web pages without the need to send requests to servers. However, today it has evolved into much more, with dozens of frameworks available. This paper will compare web frameworks based on the JavaScript programming language, which are widely known as SPA (Single Page Application) frameworks. The reason for choosing the JavaScript programming language and its frameworks is its popularity. According to the "Stackoverflow" survey from 2022, it has been the most widely used programming language for eight years in a row, currently with 65.36% usage [7]. Each framework has its own specific set of characteristics, and each of them does certain things better. For example, a comparison will be made of three applications developed with Angular, Vue, and React frameworks. Choosing a web application framework involves evaluating certain factors that can affect application development. Although they are relatively easy to measure, application performance is often given little attention. Application performance directly affects implementation and maintenance costs, which can ultimately make the product inefficient. Poor performance can cause premature and costly maintenance, as well as additional optimization. In the end, such applications lead to poor user experience, reducing its quality.

To measure performance and obtain the necessary parameters for comparison, the "Google Chrome Developer Tool" was used. The tool is part of the Google Chrome browser, used for testing, diagnosing problems, and help develop web applications [8].

2. Theory part

JavaScript is the most popular programming language according to GitHub, according to statistics it remains at the top for the eighth year in a row, while its follower is Python [9]. Knowledge of the JavaScript programming language is highly valued among programmers. Web applications built in this language are supported by all popular browsers, and various tools are available that make programming and error finding easier. Additionally, it is possible to create desktop applications for Windows and Mac, as well as applications for smartphones and tablets, and server applications [1].

JavaScript is unique in the world of programming. It is much more fluid and flexible, and it loads and executes easily in the browser. It is among the programming languages that are constantly evolving, and browsers must keep up with this development, so older browsers may not support every function. By updating the browser, it is ensured that already existing applications remain functional, that is, they are fully supported by the browser [18].

2.1. Javascript framework

A web framework has become an essential part of software development, so every programming language has its specific framework. Despite this, choosing the appropriate framework can be challenging due to the existence of many frameworks on the market and the factors that need to be considered. Frameworks as a technology were created to establish software concepts and designs, as well as to reduce the costs of implementing applications with improved quality. According to Fayad and Schmidt, the main advantages of using frameworks are modularity, reusability, extensibility, and inversion of control [20]. The two most common types of web development frameworks are server-side and client-side frameworks. Server-side frameworks run on the web server, while client-side frameworks run in the web browser. Server-side frameworks are usually called "backend," and client-side frameworks are called "frontend" [10]. The quality and performance of the most popular JavaScript frameworks were evaluated in the study, taking into account software quality factors and performance tests. The aim is to present the advantages and disadvantages of JavaScript frameworks in different areas, identify problematic points, and suggest possible improvements in future versions [2]. The research was conducted on three popular frameworks: React, Angular, and Vue.js. Figure 1 shows statistical data on the popularity of the three selected frameworks.

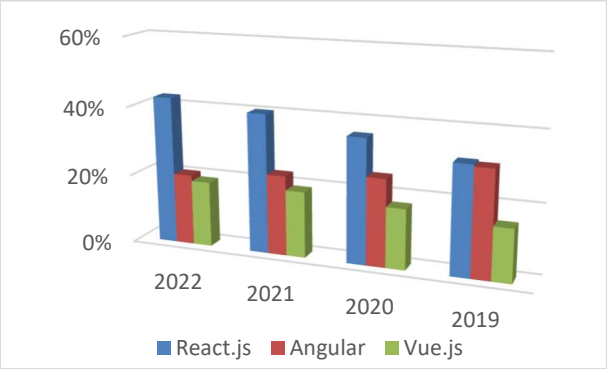


Figure 1. Popularity of Javascript frameworks.

According to the Github survey, React is the most popular front-end framework (with a growing trend). Additionally, React is a suitable and desirable front-end framework (although its increased usage has led to a decrease in user satisfaction) [12].

2.1.1. React framework. A popular framework for building user interfaces, React is built around components. Components are self-contained modules that render some output and can be UI elements such as buttons or input fields. Components are composable, meaning they can include one or more other components as their outputs. The entire structure of the application is made up of components that communicate with each other. React doesn't execute directly on the Document Object Model

(DOM), but rather on a virtual DOM. After the virtual DOM is updated, React detects changes and updates them on the current DOM in the browser. React uses a JavaScript extension called JSX, which produces React elements that are later rendered in the DOM. Instead of separating HTML and logic into separate files, JSX combines them into one, essentially representing HTML and JavaScript code as one.

2.1.2. Angular framework. Angular, often referred to as Angular 2+ or Angular 2, is an open-source JavaScript frontend web framework developed by Google in 2016, designed for complex web applications. Angular is a complete successor to the older version of AngularJS, which was created in 2010 [3]. Angular uses the TypeScript programming language, which is essentially an extended version of JavaScript with several advanced features. TypeScript is compiled into JavaScript, so they are tightly linked. Angular is also composed of components. Components are structured so that the logical part is separated from the hypertextual part. Additionally, components are presented in the form of classes, which can be used in multiple places or nested [4].

2.1.3. Vue.js framework. Vue is an open-source JavaScript frontend framework for building user interfaces and single-page applications. It was created in 2014 by Evan You and is focused on the view layer, i.e. visual content only. Vue extends HTML using attributes called directives, which provide functionality to HTML applications and come as built-in or user-defined. Vue components extend basic HTML elements to encapsulate them in reusable code. Components are arbitrary elements through which Vue adds functions to elements with predefined options [19].

2.1.4. Developer tool. It represents a group of tools for developers built directly into the Google Chrome web browser. The DevTool tool can modify the page, customize it, diagnose problems, greatly facilitating the development of the application in a faster and better way. With this tool, it is possible to manipulate the DOM or styles (CSS - Cascade Style Sheet) directly in the browser, as well as debug JavaScript and analyze performance. Although it may seem quite complicated to use, proper use can increase productivity [17].

2.2. Description of the problem

In the paper, a framework was examined by taking into account various factors, i.e., those parameters that can be tested; the way they can be tested and based on that knowledge, evaluate three selected frameworks (React, Angular, and Vue.js). In solving the task, it is necessary to find an answer to two questions:

- How to evaluate a framework?
- Which parameters to compare?

Framework ratings are determined using measurable parameters, such as: performance of DOM manipulation, creating, updating, and deleting data from the DOM. Additionally, one of the parameters is memory usage, startup time, and overall application weight [5].

3. The results

All three frameworks are the most commonly chosen frameworks for frontend web applications. They have similarities but are not the same, so it's good to compare them to get to know their differences. Each of the frameworks is based on components and allows for fast web application development.

3.1. The popularity of the framework

There are several ways to check the popularity of a framework. In this paper, popularity will be consulted in relation to several sources that deal with such issues: Google searches, NPM (Node package manager) download number, GitHub ratings (GitHub stars), number of implemented applications for each framework, and the most sought-after technology in the market.

3.1.1. Google searches. The popularity analysis was performed according to Google searches using the Google Trends tool and the results were obtained for various keywords. Comparing the three frameworks for 2022, the following results are obtained, as shown in Figure 2.

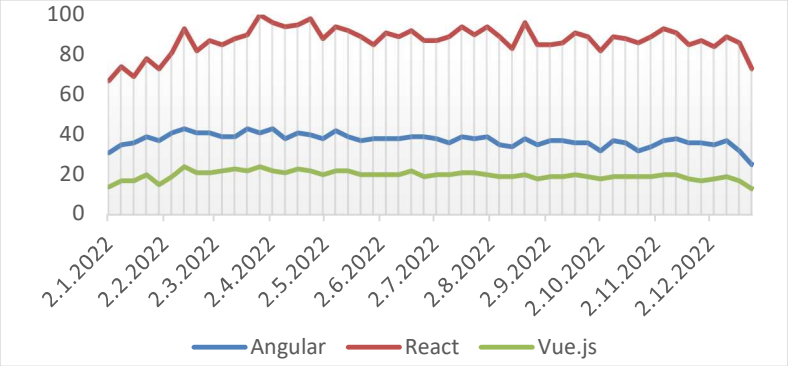


Figure 2. Display of the most searched frameworks according to Google Trends.

According to Figure 2, React framework has the highest number of searches, while Vue.js is the least searched. Regional search data shows that Vue.js is the most searched in the region of China, while Angular is the most searched for Spain, Germany, and Italy [13].

3.1.2. NPM Trends. The tool that enables exploring and comparing most NPM packages is available on the website npmtrends.com. NPM trends can be used to track the increase in package adoption, i.e., which packages are the most popular and widely used, as shown in Figure 3.

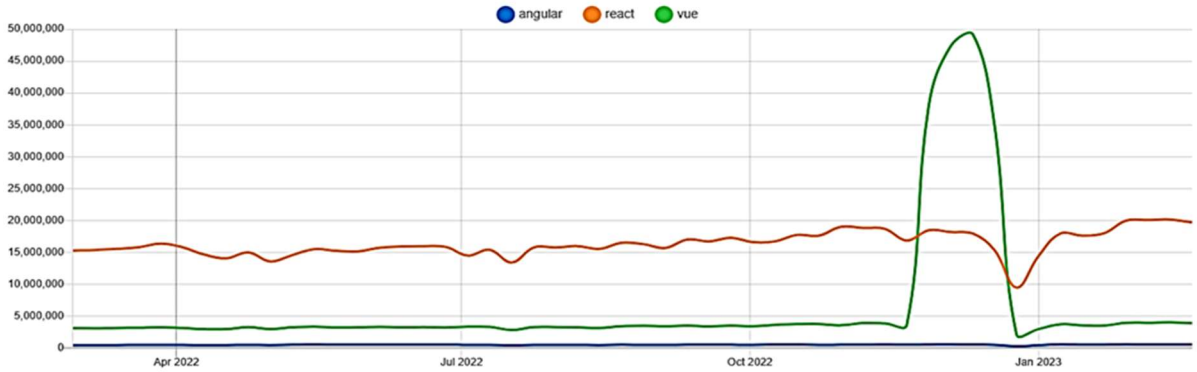


Figure 3. NPM trends, framework popularity according to the number of downloads.

Multiple measuring methods can be used when analyzing NPM trends, such as the total number of downloads from the internet, downloads for a specific time period, or the number of dependent packages [14].

3.1.3. GitHub Stars. Users of GitHub have the option to star repositories of other users. This way, stars can indicate that they like the project or simply to bookmark it to receive information about any changes, as shown in figure 4.

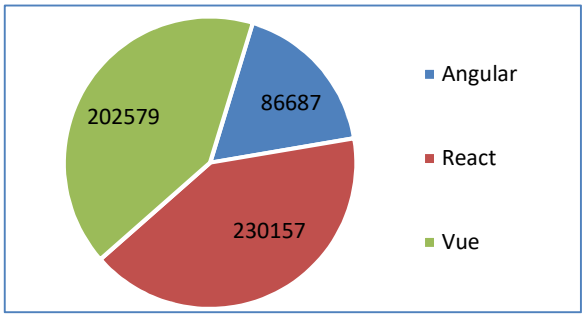


Figure 4. GitHub stars, the number of stars of popular frameworks.

GitHub is a repository for millions of repositories. GitHub stars are a simple indicator for tracking and can be used to measure the popularity of a project. According to the statistics in Figure 4, Vue and React are roughly equal, while Angular lags behind considerably [6].

3.1.4. Number of applications for each of the frameworks. The popularity parameter of a framework can also be analyzed through the number of applications developed with it, as shown in figure 5. In this regard, the popular website buildwith.com tracks and measures such data, where each website uses some of the technologies.

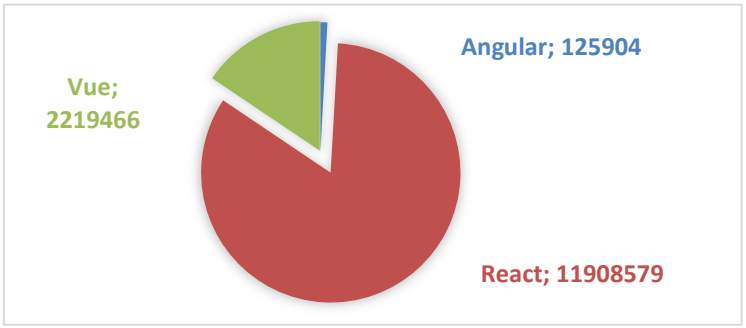


Figure 5. Buildwidth statistics according to the number of applications for each of the frameworks.

According to the data in Figure 5, we can see that React is superior compared to the other two frameworks [15].

3.1.5. Most wanted frameworks by employers. The indicator of a framework's rating can also be the demand in the job market, as shown in figure 6. For this purpose, data from the well-known job and employment platform linkedin.com can be used, taking into account the results of job searches. The number of jobs is shown for the European Union region.

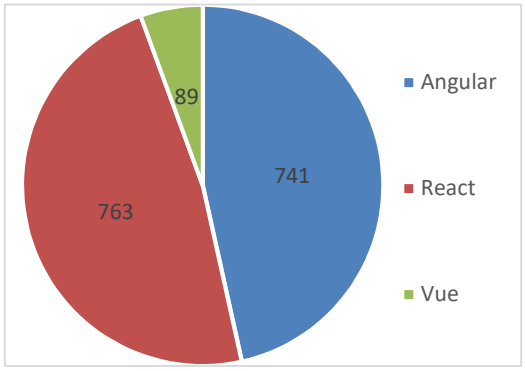


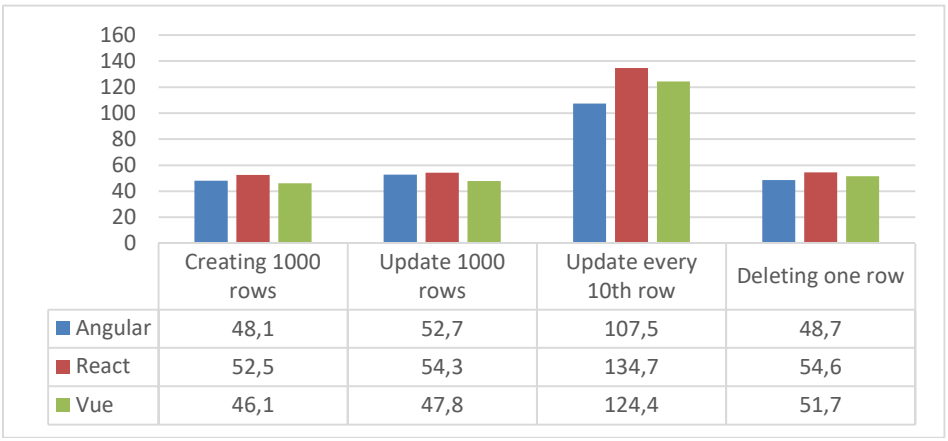
Figure 6. Number of jobs for three frameworks according to linkedin.com.

According to Figure 6, the most published job ads on linkedin.com for React and Angular are tied, while the representation of Vue is the lowest [16].

3.2. Performance comparison

During project developing, it is important to take into account the application's performance, which is why it makes sense to compare them for the selected three frameworks. Performance comparison, or speed, should not be the only important factor. It is necessary to maintain development quality and follow certain programming conventions. The Developer Tools tool, which is part of the Google Chrome browser, was used to measure performance. Testing was done on a MacBook Pro 14 computer, with 32 GB of RAM, 8/16 core processors, OSX 13.2 operating system, and Google Chrome 1100.0.5481.77 (arm64) web browser. Tests were performed for the following versions: Angular v15.0.1, React v17.0.2, and Vue v3.2.37.

3.2.1. Table manipulation speed testing. Testing the speed of table manipulation, i.e., creating, updating, deleting, and swapping rows is important for analyzing row manipulation tests in a table. The measurements were performed in milliseconds according to figure 7.



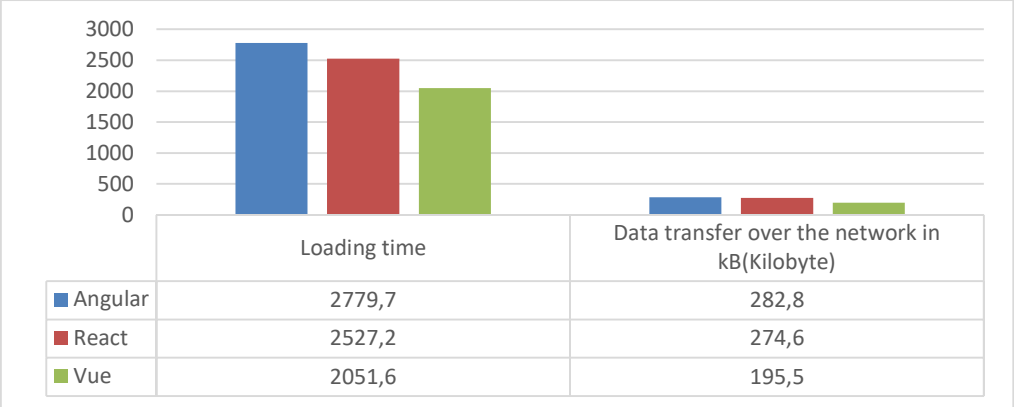
	Creating 1000 rows	Update 1000 rows	Update every 10th row	Deleting one row
Angular	48,1	52,7	107,5	48,7
React	52,5	54,3	134,7	54,6
Vue	46,1	47,8	124,4	51,7

Figure 7. Table row manipulation tests.

Based on the results obtained according to figure 7, a certain advantage of the Vue framework can be determined, except in some cases where it gives worse results. While Angular shows good results in manipulating the DOM, the results of updating every 10th row show the opposite.

3.2.2. Start-up time and data transfer. One very important test is the application startup time. The obtained results are interesting because there are significant differences. The application startup is

completed when the processor finishes all tasks. Additionally, data transfer usage over the network and the time it takes to load all sources on the page were measured, as shown in figure 8.



	Loading time	Data transfer over the network in kB(Kilobyte)
Angular	2779,7	282,8
React	2527,2	274,6
Vue	2051,6	195,5

Figure 8. Display of application loading speed and amount of data transfer over the network.

The test results according to figure 8 show that the fastest loading speed is in the Vue framework application. Based on the results, this can also be assumed, as Vue takes up extremely little memory, which allows for a significant reduction in startup time and data transfer usage over the network.

3.2.3. Memory allocation. According to memory allocation data, Angular shows worse results compared to the other two frameworks. React and Vue show quite similar results regarding memory allocation, as shown in figure 9.

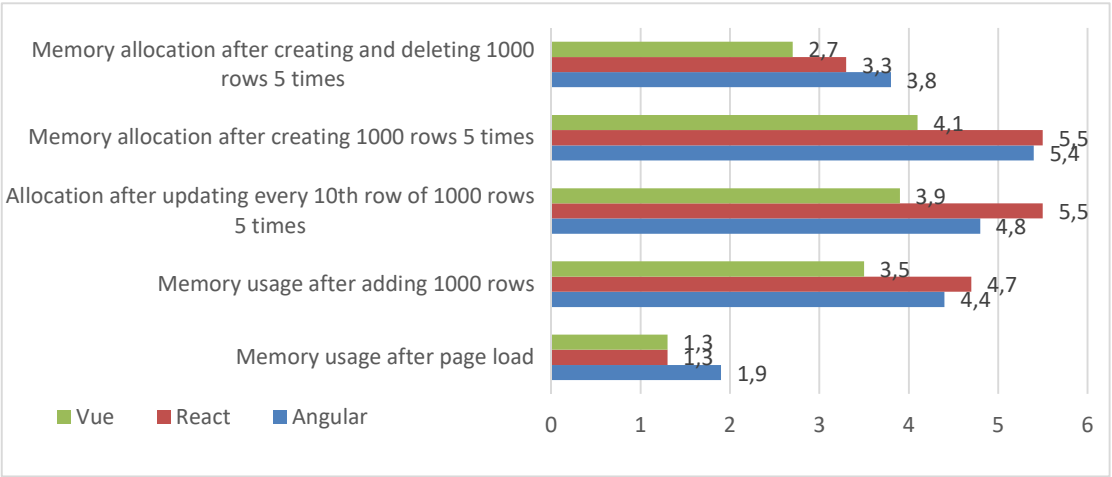


Figure 9. Display of memory allocation test results in MB (Megabyte).

According to the diagram in Figure 9, it can be observed that Angular is slower compared to Vue and React frameworks. The performance of Vue and React is very good, so there is no significant difference between them.

4. Conslusion

The choice of a suitable framework among the three listed depends on the analysis of application loading speed and the amount of data transfer over the network. Some frameworks are more suitable for certain use cases than others. All three listed frameworks are sufficiently adaptable to be used in all types of projects. The Angular framework is most suitable for large projects due to its organizational structure, but any of the listed frameworks can be used with sufficient knowledge of architecture and

web development. All three frameworks have an active community and a large amount of documentation, support, and a large number of available courses. In terms of performance, they are quite similar. Angular, React, and Vue frameworks are continuously developed and upgraded. New versions are regularly released, and existing ones are maintained. Since the support is very high, in any case, it is possible to use any of the three frameworks. Currently, the Angular framework has slower growth, while the Vue framework is very progressive. The aim of this work was to compare and analyze, and explain the architectural differences. When choosing a framework, other factors such as a sufficient number of programmers for a particular framework should also be taken into account. This work presents only a part of the possibilities for comparison, and testing can be expanded to other areas such as data processing, working with multimedia content, and communication with API (Application Programming Interface) services.

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Approximation of Periodic Signals using Fourier Series

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Abstract. This work defines the concepts of a periodic function, trigonometric and Fourier series, and derives formulas for determining Fourier coefficients. It also presents and describes the approximation of periodic signals using Fourier series, which represents a key tool in signal theory. Fourier series enable the decomposition of a periodic signal into an infinite number of sinusoidal or cosinusoidal functions of different frequencies. In this way, we can determine the frequency content of the signal, identify its frequency components, and observe the difference between the fundamental frequency (fundamental harmonic) and higher harmonics, which indicate the presence of noise or disturbances. Essentially, Fourier series allow for the analysis, synthesis, and manipulation of periodic signals, resulting in a better understanding of the signal's frequency content and enabling signal customization and processing according to desired needs. The approximation of periodic signals using Fourier series is commonly employed in practice because periodic signals can be well approximated with a relatively small number of harmonics.

1. Introduction

One of the most powerful and commonly used tools for modeling periodic signals is Fourier analysis. Joseph Fourier, an 18th-century French mathematician, developed the Fourier series as a method of decomposing periodic functions into a sum of sinusoidal and cosine functions. This series is often referred to as the Fourier series. Fourier analysis enables the representation of periodic signals using an infinite number of sinusoidal and cosine harmonics with different frequencies and amplitudes.

Periodic signals frequently occur in various fields such as electrical engineering, telecommunications, acoustics, and many others. They are characterized by the repetition of the same pattern over time. To understand and manipulate these signals, it is necessary to find an appropriate mathematical model that describes them.

The aim of this paper is to provide an introduction to the approximation of periodic signals using Fourier series. The mathematical concept of Fourier analysis, the process of decomposing periodic signals, and the methods of reconstructing the original signal from the Fourier series are presented.

2. Fourier Series

Fourier series are a mathematical tool used to decompose periodic and aperiodic functions, which can be expressed in a periodic form, into a set of sinusoidal and cosinusoidal functions known as harmonics. These series are named after the French mathematician Jean-Baptiste Joseph Fourier, who first developed the theory of Fourier series in the 19th century. Fourier argued in his analyses that any periodic function or signal can be expressed as a (not necessarily finite) sum of sine waves with different phases, amplitudes, and frequencies. Such a sum is called a Fourier series. Although the

original requirement for developing a function into a Fourier series was that the function be periodic, the same method can be applied to aperiodic functions over certain intervals, provided they are made periodic. Thus, we can consider the interval over which we observe a function as the period of that function

Definition 2.1. Let $f(x)$ be a function defined on the set $\mathbb{R}$. We say that this function is periodic with period ω, if

$$f(x+\omega) = f(x), \quad \forall x \in \mathbb{R}. \tag{1}$$

If $\omega = 0$,, then every function is considered to be periodic with period ω. Therefore, we will assume that $\omega \neq 0$, i.e., $\omega > 0$. From $f[(x-\omega)+\omega] = f(x-\omega)$we see that if the function $f(x)$is periodic with period $\omega > 0$, then it is also periodic with period $-\omega$. If $f(x)$ is periodic with period ω, then the function $f(x)$ is also periodic with period $k\omega$, where $k \in \mathbb{Z}$.

*Theorem 2.1***.** Let $f(x)$ be a periodic function with period ω and let it be integrable over one interval of length ω. Then it is integrable over every finite interval of length ω, and the following holds:

$$\int_a^{a+\omega} f(x)dx = \int_0^{\omega} f(x)dx. \tag{2}$$

Therefore, if we calculate the integral of the function $f(x)$ over an interval of length ω, it does not matter where the beginning of that interval is located. [1]

Let $f(x)$ be a 2π-periodic function. If we want to approximate it with other periodic functions, it is natural to approximate it with a simpler 2π-periodic function. Among the simplest 2π-periodic functions are functions of the form $A_k \cdot \sin(kx+\gamma_k)$where A_k and $\gamma_k$are constants, and $k \in \mathbb{N}$. It is clear that we will not be able to approximate any arbitrary 2π −periodic function with sufficient accuracy using just one such function. Therefore, we consider the sum

$$A_0 + \sum_{k=1}^{n} A_k \cdot \sin(kx+\gamma_k). \tag{3}$$

Such an expression is called a trigonometric polynomial. It is natural to consider the sum of infinitely many terms of the form $A_k \cdot \sin(kx+\gamma_k)$, i.e., a series of the form:

$$A_0 + \sum_{k=1}^{\infty} A_k \cdot \sin(kx+\gamma_k). \tag{4}$$

This series is called a trigonometric series. By using the addition theorem, we can express the term $A_k \cdot \sin(kx+\gamma_k)$in the form:

$$A_k \cdot \sin(kx+\gamma_k) = a_k \cos kx + b_k \sin kx, \tag{5}$$

where $a_k = A_k \sin kx$, $b_k = A_k \cos kx$.

Now, the trigonometric polynomial can be written as:

$$\frac{a_0}{2} + \sum_{k=1}^{n}(a_k \cos kx + b_k \sin kx), \tag{6}$$

and the trigonometric series can be written as:

$$\frac{a_0}{2} + \sum_{k=1}^{\infty}(a_k \cos kx + b_k \sin kx). \tag{7}$$

The numbers $\frac{a_0}{2}, a_k$ and b_k are called the coefficients of the trigonometric series. The coefficient $\frac{a_0}{2}$ is referred to as the constant term.

Let's assume that the previous trigonometric series converges for $x \in [-\pi, \pi]$Since the terms of this series are clearly 2π-periodic functions, the trigonometric series actually converges for every $x \in \mathbb{R}$. We denote the sum of this series as $f(x)$. It is clear that $f(x)$ is also a 2π-periodic function. Therefore,

$$f(x) = \frac{a_0}{2} + \sum_{k=1}^{\infty}(a_k \cos kx + b_k \sin kx), \quad x \in \mathbb{R}. \tag{8}$$

Naturally, we question the relationship between the function $f(x)$ and the coefficients of the trigonometric series. If we assume nothing else about the series other than its convergence for $x \in [-\pi, \pi]$, then we cannot say anything more specific about this relationship. Let's assume that the given series uniformly converges on $[-\pi, \pi]$, and therefore on the entire set $\mathbb{R}$ due to the periodicity of its terms. In that case, the sum $f(x)$ of the series will be a continuous function for every x. Additionally, the series can be integrated term by term, so by integrating it, we obtain:

$$\frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx = \frac{a_0}{2} \cdot \frac{1}{\pi} \int_{-\pi}^{\pi} dx + \sum_{k=1}^{\infty}\left(a_k \frac{1}{\pi}\int_{-\pi}^{\pi} \cos kx\, dx + b\frac{1}{\pi}\int_{-\pi}^{\pi} \sin kx\, dx\right). \tag{9}$$

All the integrals on the right-hand side, which are under the $\sum$ symbol, are clearly equal to zero, so we obtain:

$$\frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx = a_0. \tag{10}$$

Now, let's take a fixed number n. By multiplying by $cos(nx)$ and then integrating from $-\pi$ to π, we have:

$$\frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx\,dx = \frac{a_0}{2}\cdot\frac{1}{\pi}\int_{-\pi}^{\pi}\cos nx\,dx + \sum_{k=1}^{\infty}\left(a_k\frac{1}{\pi}\int_{-\pi}^{\pi}\cos kx\cos nx\,dx + b\frac{1}{\pi}\int_{-\pi}^{\pi}\sin kx\cos nx\,dx\right) \tag{11}$$

From the last equation, we obtain:

$$\frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx\,dx = a_n\frac{1}{\pi}\int_{-\pi}^{\pi}\cos^2 nx\,dx. \tag{12}$$

Since $\int_{-\pi}^{\pi}\cos^2 nx\,dx = \pi$, the above relation becomes:

$$\frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx\,dx = a_n. \tag{13}$$

In a similar manner, by multiplying the equation by $sin(nx)$ and then integrating from $-\pi$ to π, we obtain:

$$\frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin nx\,dx = b_n. \tag{14}$$

Therefore, we have obtained the formulas for the coefficients of the series:

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx\,dx, \quad n = 0,1,2,\dots$$

$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin nx\,dx \quad n = 1,2,3,\dots \tag{15}$$

The fact that the trigonometric series is formed using the Fourier coefficients is denoted as:

$$f(x)\sim\frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n\cos nx + b_n\sin nx). \tag{16}$$

The last relation simply signifies that the coefficients on the right side of the equation are calculated using the previously derived formulas. However, whether the Fourier series of the function $f(x)$ converges at a particular point, and if it does converge, whether its sum is equal to $f(x)$, needs to be separately investigated. [2]

Theorem 2.2. If a trigonometric series is uniformly convergent on $[-\pi,\pi]$, and therefore on the set $\mathbb{R}$, then it is the Fourier series of its function.

Now let's assume that the function $f(x)$ is defined on the interval $[-l,l]$ of arbitrary length $2l$ ($l > 0$). If we set: $x = \frac{ly}{\pi}$, $-\pi \le y \le \pi$, we obtain the function $f\left(\frac{ly}{\pi}\right)$ on the interval $[-\pi,\pi]$, which is the case we have already considered. Under the appropriate assumptions, the function can be expanded into a Fourier series:

$$f\left(\frac{ly}{\pi}\right) = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n\cos ny + b_n\sin ny), \tag{17}$$

with coefficients given by the formulas:

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{ly}{\pi}\right)\cos ny\,dy, \quad n = 0,1,2,\dots$$

$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{ly}{\pi}\right)\sin ny\,dy \quad n = 1,2,3,\dots \tag{18}$$

Now let's revert to the variable x by setting $y = \frac{\pi x}{l}$. We obtain the decomposed given function $f(x)$ into a trigonometric series of a slightly modified form:

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left(a_n\cos\frac{n\pi x}{l} + b_n\sin\frac{n\pi x}{l}\right). \tag{19}$$

Here, the sines and cosines are taken not with respect to the angle x, but with respect to the angle $\frac{n\pi x}{l}, n \in \mathbb{N}$. With the same substitution, we can also transform the formulas for determining the coefficients of this expansion:

$$a_n = \frac{1}{l}\int_{-l}^{l} f(x)\cos\frac{n\pi x}{l}dx, \quad n = 0,1,2,\dots$$

$$b_n = \frac{1}{l}\int_{-l}^{l} f(x)\sin\frac{n\pi x}{l}dx \quad n = 1,2,3,\dots \tag{20}$$

Finally, the interval $[-l,l]$ can be replaced with any other interval of length $2l$. [2]

These formulas are derived for the case when the periodic function is observed on a symmetric interval $[-l, l]$. However, when we observe the function on an arbitrary interval $[a, b]$ of length $T = b - a$, the Fourier series takes the form:

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left(a_n \cos\frac{2n\pi x}{T} + b_n \sin\frac{2n\pi x}{T}\right), \quad (21)$$

where the coefficients are defined using the formulas:

$$a_n = \frac{2}{T}\int_a^b f(x)\cos\frac{2n\pi x}{l}\,dx, \quad n = 0,1,2,\ldots$$
$$b_n = \frac{2}{T}\int_a^b f(x)\sin\frac{2n\pi x}{l}\,dx \quad n = 1,2,3,\ldots \quad (22)$$

The mathematical rigor of the Fourier series was established by the German mathematician Dirichlet by providing sufficient conditions under which a function can be represented using a Fourier series. If a function satisfies Dirichlet's conditions, then the convergence of its Fourier series can be determined.

Definition 2.2. We say that a function $f: [a, b] \to \mathbb{R}$ is piecewise continuous on $[a, b]$ if it is continuous on that interval or if it has only finitely many points of discontinuity on that interval.

For a point $= x_0$, we say that it is a point of first kind discontinuity of the function $f(x)$ if both the left and right limits of the function at that point, $f(x_0-)$ and $f(x_0+)$, exist and are finite, but they are different.

Definition 2.3. We say that a function $f(x)$ satisfies Dirichlet's conditions on the interval $[a, b]$ if the following hold:

a) $f(x)$ is piecewise continuous on the interval $[a, b]$, and all its discontinuities are of the first kind.

b) $f(x)$ is either a monotonic function on the interval $[a, b]$ or has at most finitely many extrema on that interval.

Theorem 2.3. If $f(x)$ is a periodic function with period 2π, and it satisfies Dirichlet's conditions on the interval $[-\pi, \pi]$, then its Fourier series converges on the interval $[-\pi, \pi]$ to a function $S(x)$, where:

a) $S(x) = f(x)$ at every point x where the function $f(x)$ is continuous,

b) $S(x) = \frac{f(x-)+f(x+)}{2}$ if x is a point of discontinuity of the function $f(x)$, and

c) $S(\pi) = S(-\pi) = \frac{f(-\pi+)+f(\pi-)}{2}$.

The Fourier series of a function $f(x)$ can be expressed in complex form. Let's consider:

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n \cos nx + b_n \sin nx). \quad (23)$$

Let's express the coefficients as:

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx\,dx, \quad n = 0,1,2,\ldots$$
$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin nx\,dx \quad n = 1,2,3,\ldots \quad (24)$$

Now, let's substitute n with $-n$. We have:

$$a_{-n} = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos(-nx)\,dx = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx\,dx = a_n, \quad n = 1,2,3,\ldots,$$
$$b_{-n} = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin(-nx)\,dx = -\frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin nx\,dx = -b_n \quad n = 1,2,3,\ldots. \quad (25)$$

Given that: $\cos x = \frac{e^{ix}+e^{-ix}}{2} \wedge \sin x = \frac{e^{ix}-e^{-ix}}{2i}$, it follows that $\cos nx = \frac{e^{inx}+e^{-inx}}{2} \wedge \sin nx = i \cdot \frac{e^{-inx}-e^{inx}}{2}$. Substituting these into the equation, we have

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left(a_n \cdot \frac{e^{inx}+e^{-in}}{2} + b_n \cdot i \cdot \frac{e^{-in} - e^{inx}}{2}\right) =$$
$$= \frac{a_0}{2} + \sum_{n=1}^{\infty}\left(e^{inx}\frac{a_n - ib_n}{2} + e^{-inx}\frac{a_n + ib_n}{2}\right) =$$
$$= \frac{a_0}{2} + \sum_{n=1}^{\infty} e^{inx}\frac{a_n - ib_n}{2} + \sum_{n=1}^{\infty} e^{-inx}\frac{a_n + ib_n}{2} \quad (26)$$

If we replace n in the second sum with $-n$, then from $n|_1^{\infty}$ we get $-n|_{-1}^{-\infty}$ and we can write the last equality as $f(x) = \frac{a_0}{2} + \sum_{n=1}^{+\infty} e^{inx}\frac{a_n - ib_n}{2} + \sum_{n=-1}^{-\infty} e^{inx}\frac{a_n - ib_n}{2}$. Since $b_0 = 0$, we can write the first

term in the previous equation as $\frac{a_0}{2} = \frac{a_0 - ib_0}{2}$, and express the equation as a single sum: $f(x) = \sum_{n=-\infty}^{+\infty} e^{inx} \frac{a_n - ib_n}{2}$. Alternatively, if we define $a_n - ib_n = c_n$, then we have:

$$f(x) = \frac{1}{2} \sum_{n=-\infty}^{+\infty} e^{inx} c_n. \tag{27}$$

Let $f(x)$ be defined on the interval $[-\pi, \pi]$. Then its Fourier series expansion in complex form is given by [2]

$$f(x) = \frac{1}{2} \sum_{n=-\infty}^{+\infty} e^{inx} c_n, \quad c_n = \frac{1}{2\pi} \int_{-\pi}^{\pi} f(x) e^{-inx} dx. \tag{28}$$

3. Application of Fourier Series

Fourier series is a mathematical tool developed by the French mathematician Joseph Fourier in the 19th century. This tool has had a revolutionary impact on many scientific and engineering fields, and today it represents one of the fundamental tools for the analysis and processing of periodic signals. Joseph Fourier, inspired by the problem of heat conduction, developed a theory for decomposing periodic functions into an infinite sum of sinusoidal functions. His key idea was that a periodic function could be approximated as an infinite sum of harmonics, with coefficients depending on the frequency and amplitude of each harmonic.

The application of Fourier series is of great significance as it enables a deeper understanding of periodic phenomena and their mathematical analysis. Fourier series have become the foundation for the development of a broader field of mathematical analysis. In mathematics, Fourier series are crucial for understanding functions, convergence, analytical properties, and solving differential equations. Many phenomena in electrical engineering are periodic, and Fourier series provide the basis for their analysis. They are used for extracting frequency components of signals, filtering noise, data compression, modulation and demodulation of signals, signal reconstruction, and more. Without the use of Fourier series, integrating and differentiating complex signal forms would be very challenging. By using Fourier series, the integration and differentiation of complex functions can be reduced to the integration and differentiation of trigonometric functions, which is a much simpler process. In electronic devices, signals other than sinusoidal ones are often required.

However, it can be difficult to continue calculations with certain signal forms, so they need to be approximated. Periodic signals can be approximated using Fourier series. One such signal is the Square (rectangular wave) signal, where half of the period has the signal amplitude above zero.
Mathematically, the square signal is defined as:

$$x(t) = \begin{cases} A, & 0 \le t < \frac{T}{2} \\ -A, & \frac{T}{2} \le t < T \end{cases},$$

where $x(t)$ represents the signal value at time t. [3]

The square signal has a period T, which means its pattern repeats every T time units. The signal is symmetric with respect to zero, meaning it has equal lengths for its positive and negative parts. The values of the square signal are $+A$ and $-A$, where A represents the signal's amplitude. The square signal maintains a constant value of A during the first part of the period, and then abruptly transitions to a constant value of $-A$ during the second part. This sudden change is referred to as a step.
The square signal has a rich spectrum consisting of the fundamental frequency and an infinite number of harmonics. The fundamental frequency is the reciprocal of the signal's period ($f = 1/T$), and the harmonics are multiples of the fundamental frequency. Square signals have a wide range of applications in various fields. For example, in electronics, square signals are often used for testing electrical circuits and systems. In music, they are used for generating specific tones or effects. Additionally, square signals are utilized in digital signal processing for testing the performance of filtering and modulation algorithms. [3]

Example 1. Let's consider a square signal that is defined as follows:

$$f(x) = \begin{cases} 1, & 0 \le x < \frac{T}{2} \\ -1, & \frac{T}{2} \le x < T \end{cases}.$$

Based on this defined function (square signal), we can determine the Fourier coefficients, which represent its representation in a Fourier series.

$$a_0 = \frac{1}{T}\int_0^T f(x)dx = \frac{1}{T}\int_0^{\frac{T}{2}} dx - \frac{1}{T}\int_{\frac{T}{2}}^T dx = \frac{1}{T}\left(\frac{T}{2} - 0 - T + \frac{T}{2}\right) = 0.$$

$$a_n = \frac{2}{T}\int_0^T f(x)\cos\frac{2n\pi x}{l}dx = \frac{2}{T}\left(\int_0^{\frac{T}{2}}\cos\frac{2n\pi x}{T}dx - \int_{\frac{T}{2}}^T \cos\frac{2n\pi x}{T}dx\right) =$$

$$= \frac{2}{T}\cdot\frac{T}{2n\pi}\cdot[(\sin n\pi - \sin 0) - (\sin 2n\pi - \sin n\pi)] = 0.$$

$$b_n = \frac{2}{T}\int_0^T f(x)\sin\frac{2n\pi x}{l}dx = \frac{2}{T}\left(\int_0^{\frac{T}{2}}\sin\frac{2n\pi x}{T}dx - \int_{\frac{T}{2}}^T \sin\frac{2n\pi x}{T}dx\right) =$$

$$= \frac{2}{T}\cdot\frac{T}{2n\pi}\cdot[(-\cos n\pi + \cos 0) + (\cos 2n\pi - \cos n\pi)] = \frac{2(1-\cos\quad)}{n\pi}.$$

Therefore, only the coefficients b_n with odd indices are non-zero, and we have the following relationship:

$$b_n = \begin{cases} 0, & if\ n\ is\ even \\ \frac{4}{\pi n}, & if\ n\ is\ odd \end{cases}.$$

Therefore, the Fourier series of the given function is of the form:

$$\frac{4}{\pi}\sin\frac{2\pi x}{T} + \frac{4}{3\pi}\sin\frac{6\pi x}{T} + \frac{4}{5\pi}\sin\frac{10\pi x}{T} + \frac{4}{7\pi}\sin\frac{14\pi x}{T} + \cdots = \sum_{n=0}^{\infty}\frac{4}{\pi(2n+1)}\sin\frac{2\pi(2n+1)x}{T}.$$

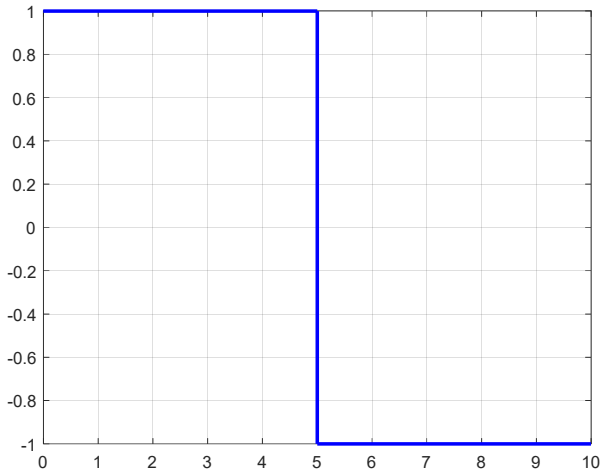

Figure 1. Square signal.

The following images show the approximation of the given square signal using the Fourier series for different values: $T = 10, n = 6,\ n = 16$ and $n = 32$.

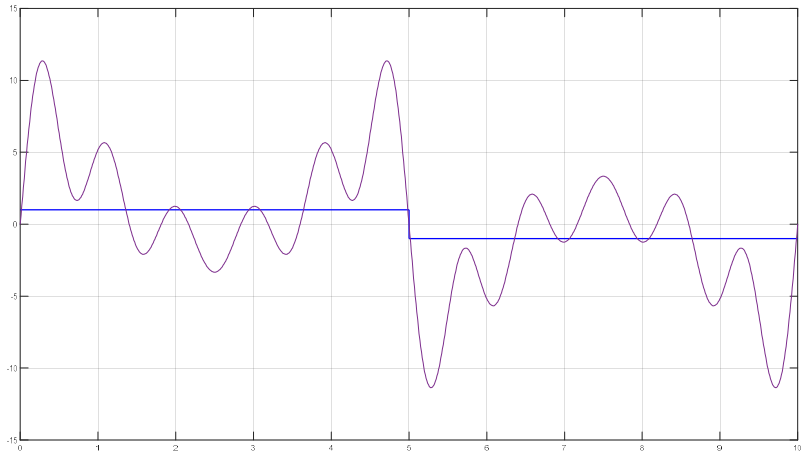

Figure 2. The square signal and its Fourier series for $n = 6$.

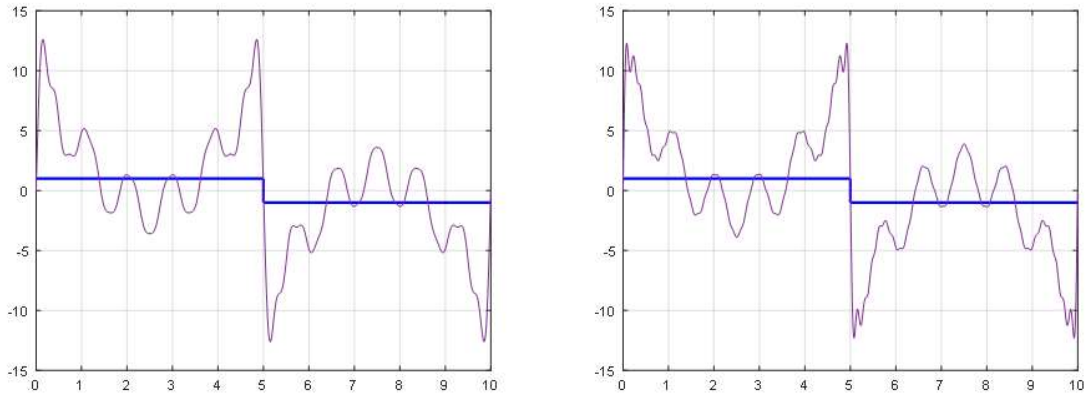

Figure 3. The square signal and its Fourier series for $n = 16$ and $n = 32$.

The images clearly demonstrate that by adding a greater number of trigonometric functions (increasing n), the approximated function gets closer and closer to the original function.

4. Conclusion

Fourier series is a mathematical tool used for approximating periodic signals. Its application is wide-ranging, encompassing many areas of science and technology, making it a foundation for the analysis, processing, and understanding of signals and phenomena occurring in nature. The approximation of square signals involves decomposing the signal into a sum of harmonics with different frequencies. In fact, using Fourier series, we can break down the square signal into a sum of sinusoidal harmonics, where each harmonic has its own amplitude and frequency. This approximation may have deviations from the actual square signal, especially in areas where sudden changes in signal values are present. However, as the number of harmonics increases, the approximation of the square signal becomes more accurate.

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Maxwell's equations in integral and differential form

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Abstract. Vector analysis is a field of mathematics whose subject is the differential and integral calculus of vector functions. In this paper, we present the connection between vector analysis and one part of physics, electromagnetism, where we give the characterization of electric and magnetic fields through Maxwell's four equations in integral and differential form.

1. Introduction

Maxwell's equations present a mathematical model of the physical behavior of electric and magnetic fields which, due to their mutual interaction, we connect into a single electromagnetic theory. Electromagnetic theory represents the key to the development of electrical engineering, and the significance of Maxwell's equations is still reflected in telecommunications and modern physics. The first version of Maxwell's equations was complex, but thanks to the development of vector analysis, these equations are just presented in the modern language of vector analysis using the concepts of divergence and rotation of electric and magnetic fields. The four Maxwell equations interpret: Gauss's law for the electric field, Gauss's law for the magnetic field, Faraday's law of electromagnetic induction and Ampere-Maxwell's law.

2. Vector analysis

In the theory of scalar and vector functions of position, we can generalize the term derivative in such a way that the limit process includes the values of the function at all points belonging to the neighborhood of the fixed point M. The procedure of generalizing the derivative in the direction is called spatial differentiation, and the result to which this procedure leads is called the spatial derivative. Consider a function $\varphi(\overrightarrow{r})$ which can be a scalar or vector position function. Let us see in the field of this function some point M and one area $\bar{V}$ (part of space) bounded by a closed oriented surface S such that $M \in \bar{V}$. Let $mes\,\bar{V} = V$ be the measurement number of the volume of this area, and $d\vec{S}$ the vector surface element on the closed oriented surface S. Let us further assume that φ is an integrable function on the surface S, that is, there is an integral over the closed surface $S, I = \iint_S \varphi(\overrightarrow{r}) * d\vec{S}$.

This integral can be a scalar or vector function of the magnitude V of the area $\bar{V}$ bounded by the closed surface S. Let us observe the magnitude $\frac{I}{V}$ and let the surface contract around a fixed point M, in other words let $V \to 0$.

Definition 2.1. We call the spatial derivative of the function $\varphi(\overrightarrow{r})$ the limiting value $\lim_{V\to 0} \frac{\iint_S \varphi(\overrightarrow{r}) * d\vec{S}}{V}$ if it exists.

If $\varphi(\overrightarrow{r})$ is a scalar function of position, then $\iint_S \varphi(\overrightarrow{r}) d\vec{S}$ is a vector, so the spatial derivative is also a vector which we call the gradient and denote by $\nabla\varphi(\overrightarrow{r}) = \lim_{V\to 0} \frac{\iint_S \varphi(\overrightarrow{r}) d\vec{S}}{V}$. If $\vec{\varphi}(\overrightarrow{r})$ is a vector function

of position, then depending on the type of product " $*$ " we distinguish between two cases. In the first one, where " $*$ " is a scalar product, the product $\iint_S \vec{\varphi}(\overrightarrow{r}) \cdot d\vec{S}$ represents a scalar, so the spatial derivative is also a scalar which we call the divergence of the vector field $\vec{\varphi}(\overrightarrow{r})$ and denote by $div\ \vec{\varphi} = \lim_{V\to 0} \frac{\iint_S \vec{\varphi}(\overrightarrow{r})\cdot d\vec{S}}{V}$. In the second case, where " $*$ " is a vector product, the product $\iint_S \vec{\varphi}(\overrightarrow{r}) \times d\vec{S}$ represents a vector, so the corresponding spatial derivative is a rotor, denoted by $rot\ \vec{\varphi} = \lim_{V\to 0} \frac{\iint_S \vec{\varphi}(\overrightarrow{r})\times d\vec{S}}{V}$.

The following theorem, known as Gauss's theorem or Ostrogradsky's theorem (or the divergence theorem), gives a connection between surface integrals of the second kind over a closed surface and the triple integral over the area enclosed by that surface.

Theorem 2.1. If for the vector function $\vec{\varphi}(\overrightarrow{r})$ there is a surface integral over the closed surface S which is the boundary of the region $\overline{D}$ and if $div\vec{\varphi}$ is a continuous function of position in that region, then

$$\iint_S \vec{\varphi} \cdot d\vec{\sigma} = \iiint_D div\ \vec{\varphi} \cdot dD$$

where $D = mes\overline{D}$ is the measuring number of the size (volume) of this area.
Stokes' s formula represents a generalization of Green's formula and represents the connection between the surface integral over the surface S and the line integral over the contour L over the surface S.

Theorem 2.2. If $\varphi_1(x,y,z), \varphi_2(x,y,z)$ and $\varphi_3(x,y,z)$ are vector functions and $\vec{\varphi}(\overrightarrow{r})$ is vector function, $\frac{\partial\varphi_1}{\partial y}, \frac{\partial\varphi_1}{\partial z}, \frac{\partial\varphi_2}{\partial x}, \frac{\partial\varphi_2}{\partial z}, \frac{\partial\varphi_3}{\partial x}, \frac{\partial\varphi_3}{\partial y}$ continuous functions on the surface S, which rests on the contour L, then the circulation of the vector $\vec{\varphi}$ along L is equal to the rotor flux of the vector function $\vec{\varphi}$ through S that is, the equality holds

$$\oint_L \vec{\varphi} \cdot d\vec{r} = \iint_S rot\ \vec{\varphi} \cdot d\vec{\sigma}$$

2.1. Vector analysis and physics
By applying the theory of vector analysis, numerous physical phenomena can be explained, such as important facts in the theory of electromagnetism. There are many examples in which the direct application of the theory of vector fields can be observed, and in this paper we will focus primarily on two fields - electric and magnetic fields and their mutual interaction. Field theory explains, first of all, the interaction of two bodies in space and time and describes the changed properties of space that are the result of the presence of one body, and are perceived by the other body. The work in which the basics of vector field theory are presented is *A Treatise on Electricity and Magnetism* Jamesa Clerka Maxwella [6]. Maxwell made a great contribution to science because he synthesized the theory of electricity and magnetism into one unique theory - the electromagnetic theory, which is the basic theory used to describe phenomena in electrical engineering [7],[2].

3. Maxwell's equations

The equations of electrodynamics have both an integral and a differential form. The integral form expresses the flux of a vector through a closed surface or the integral of the corresponding vector along a closed curve as the circulation of the vector along a closed contour. Following the exposition from [4], the basic task of integral interpretations consists precisely in the characteristic that they interpret only the summary data on the distribution of the amount of electricity and the field that springs or sinks in the observed area, without defining their local distribution. In order to get to these local relations of sources and field parameters, it is necessary to transform the equations from integral form to differential form, which is achieved by approaching the limit value if the domain around the observed point tends to zero.

The following four partial differential equations, known as Maxwell's equations, represent a complete description of the behavior of electric and magnetic fields in a vacuum:

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{B} = \mu_0 \vec{j} + \varepsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}$$

Vector analysis with all its theory gives the simplest representation of Maxwell's equations in the specified differential form. The first equation describes how electric fields are induced by charges. The second equation says that there is no magnetic monopole. The third equation describes the induction of electric fields by changing magnetic fields, and the fourth equation describes the creation of magnetic fields by electric currents and the induction of magnetic fields by changing electric fields. By including the displacement current, these equations treat electric and magnetic fields on an equal basis- electric fields can induce magnetic fields and vice versa.

The first Maxwell's equation says that electric charges are the sources or sinks of electric field forces, while the second Maxwell's equation says that there is no magnetic charge, that is, that magnetic field forces have neither sources or sinks.Gauss's theorem is one of the fundamental laws of electrostatics that establishes a direct correlation between the electric field strength vector and the given distribution of electric loads (charges).

Gauss's law for the electric field: the total flux of the electric field $\vec{E}$ through the closed surface S is equal to the total electric charge Q enclosed by that surface divided by the dielectric constant of the vacuum ε_0:

$$\oint_S \vec{E} \cdot d\vec{S} = \frac{Q}{\varepsilon_0}$$

If no charge is enclosed by the closed surface, the output flux of the electric field strength vector is equal to zero

$$\oint_S \vec{E} \cdot d\vec{S} = 0$$

In order to obtain an expression in differential form from the integral form of Gauss's theorem, the observed point should be encompassed by an elementary surface ΔS that includes an elementary volume ΔV in which the electric charge ΔQ. In this case, Gauss's theorem can be represented by the expression:

$$\oint_{\Delta S} \vec{E} \cdot d\vec{S} = \frac{\Delta Q}{\varepsilon_0}$$

Let's divide the left and right sides of the last equation by ΔV and look for the limit value when $\Delta V \to 0$.

We get it

$$\lim_{\Delta V \to 0} \frac{\oint \vec{E} \cdot d\vec{S}}{\Delta V} = \lim_{\Delta V \to 0} \frac{\Delta Q}{\varepsilon_0 \Delta V}$$

The expression on the left side represents the divergence of the electric field $\vec{E}$ and given that the right side is the volume density of the electric load ρ then we get the Gauss theorem in differential form which reads

$$div\ \vec{E} = \frac{\rho}{\varepsilon_0}$$

respectively

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

This equation is Gauss's law for the electric field in differential form, i.e. the first Maxwell's equation that represents the established local relationship between the electric field and the electric charge density. The total flux as an integral quantity is the same as the divergence as a local or differentiated quantity.

In the continuation of the paper, we will interpret the magnetic monopole by applying vector analysis to formulate the second Maxwell's equation which suggests that the divergence of the magnetic field generated by constant electric currents is equal to zero. The term magnetic monopole, in particle physics, refers to a hypothetical elementary particle that represents an isolated magnet with only one magnetic pole (north pole without south pole and vice versa). The question is, can we produce an isolated north or south magnetic pole: for example by breaking a bar magnet in two? If we were to cut a bar magnet in half in order to separate the north and south poles, as a result we would get two magnets. New poles of the opposite polarity would be formed at the point of intersection where there were none before. Each half would have its own north and south poles. We could continue dividing into smaller and smaller levels all the way to dimensions each, even the smallest particle, behaves like a separate magnet with corresponding poles.

Since it is not possible to separate the north pole from the south pole, as can be seen in [5], we conclude that there is no isolated magnetic charge. Therefore, the total magnetic flux through the closed surface must be equal to zero, that is;

$$\oint_C \vec{B} \cdot d\vec{S} = 0$$

This equation interprets the fact that no force can even end up in the space limited by a closed surface, that is, all the forces that enter that surface must leave it. The above equation is the second Maxwell's equation in integral form, or $\nabla \cdot \vec{B} = 0$ in differential form, which precisely represents the equation of conservation of magnetic flux or Gauss's law for the magnetostatic field. This equation establishes the described principle of the continuity of magnetic field forces, i.e. the fact that the magnetic field is a sourceless field.

One of the most important preoccupations of the 19th century was the question: can an electric current in one conductor affect the appearance of a current in another conductor. The knowledge that charged particles in motion, that is, electric current creates a magnetic field in its environment was an important fact. If we look at this knowledge from the energy level, this process is the conversion of electrical energy into magnetic energy. Over time, a reverse transformation can be realized, which implies the conversion of magnetic energy into electrical energy, which would show that the electric current in one conductor can influence the occurrence of current in another conductor. This result resulted in the great discovery of Faraday's law of electromagnetic induction in 1831, which represents the backbone of the development of electrical engineering. Faraday discovered the phenomenon of electromagnetic induction experimentally.

One of the experiments he performed involves two current coils: a primary and a secondary coil, of which the primary coil is connected to a source of electrical energy.

The electromotive force e, which is induced in the secondary winding in the process of electromagnetic induction, is proportional to the coefficient of the negative change of the magnetic flux per unit of time, that is, to the negative speed of the flux change

$$e = -\frac{d\Phi}{dt}$$

The mathematical form of Faraday's law is

$$\oint_C \vec{E}\ d\vec{l} = -\frac{d\Phi}{dt} = -\frac{d}{dt}\int_S \vec{B}\ d\vec{S}$$

where the loop (contour) C bounds the open surface S.

As we are talking about the distribution of the electromagnetic field for stationary media, we can replace the total time derivatives with the partial ones, so that the above expression can be represented in the form

$$\oint_C \vec{E}\ d\vec{l} = -\int_S \frac{\partial \vec{B}}{\partial t}\ d\vec{S}$$

In order to translate the integral form of Faraday's law into the corresponding differential form, it is necessary to look for the circulation of the electric field strength vector $\vec{E}$ along the elementary closed contour Δl on which the elementary surface ΔS rests, as shown in [4]. If the left and right sides of the integral form are divided by ΔS and look for the limit value when ΔS tends to zero, for the left side we get

$$\lim_{\Delta S \to 0} \frac{\oint_C \vec{E}\ d\vec{l}}{\Delta S} = rot\ \vec{E}$$

On the right side, it is necessary to divide the flux $\Delta\Phi$ that passes through the elemental surface ΔS by it and look for the limit value when ΔS tends to zero. Thus, the vector of magnetic induction on the observed element ΔS is obtained, that is, it is valid

$$rot\ \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

which represents Faraday's law in differential form, that is, the third Maxwell's equation, which states that a changing magnetic field creates a eddy electric field.

The last equation, out of his four, was written by Maxwell in the following form

$$\nabla \times \vec{B} = \mu_0 \vec{j}$$

Let's look at the integral form of Maxwell's last equation, that is, Ampere's circular law

$$\oint_C \vec{B}\ \cdot d\vec{l} = \mu_0 \int_S \vec{j} \cdot\ d\vec{S}$$

which interprets that the line integral of the magnetic field around the closed loop (contour) C is equal to the product of the absolute magnetic permeability of the vacuum μ_0 and the current density flow through the loop. In order for the current flow to be well defined, the integral $\int \vec{j} \cdot\ d\vec{S}$ over some surface S attached to the loop C must depend on C but not on S. We can think about the flow $\vec{j}$ from some closed surface S encompassing the volume V and as about the rate at which the charge flows out of S. As the charge is a conserved quantity, the rate at which the charge flows out of S is equal to the rate of decrease of the charge contained in the volume V. Therefore,

$$\oint_C \vec{j} \cdot d\vec{S} = -\frac{\partial}{\partial t}\int_V \rho dV$$

Now, based on Gauss's theorem, we have that

$$\nabla \cdot \vec{j} = -\frac{\partial \rho}{\partial t}$$

Therefore, $\nabla \cdot \vec{j} = 0$ holds only when $\frac{\partial \rho}{\partial t} \equiv 0$.

The problem with Ampere's law is well illustrated by the following well-known example of a long straight wire terminated by a parallel plate capacitor. Let C be the loop that goes around the wire. In a situation that does not depend on time, the capacitor behaves like a break in the wire, so that current does not flow and does not create a magnetic field, and then there is no problem with Ampere's law. However, in a time-dependent situation, a transient current flows in the wire as the capacitor charges or discharges, creating a transient magnetic field. Thus, the line integral of the magnetic field around C is (transiently) non-zero. According to Ampere's circular law, the current flow through any surface connected to C should also (transiently) be non-zero.

Let S_1, S_2 be two surfaces such that the first surface S_1cuts the wire and the second surface S_2 passes between the plates of the capacitor. The surface S_1 does not present a problem with the agreement with Ampere's law since the flux $\vec{j}$ through the surface is clearly non-zero - because it cuts the wire through which the current passes. The current flow through the surface S_2 is equal to zero and thus the current flows through the surfaces S_1, S_2 are obviously different. However, both surfaces are attached to the same loop C so the fluxes according to Ampere's law should be the same. However, even though surface S_2 does not cut any electric current, it passes through a region of strong alternating electric field as it passes between the plates of the capacitor for charging or discharging.
Instead of the given formula, let's write the following

$$\nabla \times \vec{B} = \mu_0 \vec{j} + \lambda \frac{\partial \vec{\vec{E}}}{\partial t}$$

where λ is a constant. We want the flow of the right-hand side of the above equation through some loop C to be well defined, i.e. it should depend only on C and not on the specific surface S on which it is evaluated. In other words, we want to prove that the divergence of the right side is zero. This is only necessary for self-consistency since the divergence of the left side is automatically zero. So, taking the divergence of the previous equation, we get

$$\mu_0 \nabla \cdot \vec{j} + \lambda \frac{\partial \nabla \cdot \vec{\vec{E}}}{\partial t} = 0$$

We know it is

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

so by combining the previous two formulas we arrive at equality

$$\mu_0 \nabla \cdot \vec{j} + \frac{\lambda}{\varepsilon_0} \frac{\partial \rho}{\partial t} = 0$$

Now we can write

$$\nabla \cdot \vec{j} + \frac{\partial \rho}{\partial t} = 0$$

The two previous equations agree under the condition that $\lambda = \varepsilon_0 \mu_0$. So, if we perform the specified modification, the final equation has the form

$$\nabla \times \vec{B} = \mu_0 \vec{j} + \varepsilon_0 \mu_0 \frac{\partial \vec{\vec{E}}}{\partial t}$$

Therefore, the divergence of the right side is equal to zero as a consequence of the conservation of charge, so the given equation represents the fourth Maxwell's equation where the additional term is

called the displacement current (this name was given by Maxwell). Maxwell based his equations on the results of experiments and added his additional term as would make these equations self-consistent.

4. Conclusion

The paper presents an example of a rounded implementation of the theory of vector fields on the example of perhaps one of the most important and famous theories in physics, the theory of electromagnetism. With this approach, the properties of the electric and magnetic fields, which are given in the famous Maxwell's equations, which represent the unification of the theory of electricity and magnetism, are explained on the basis of the basic terms of vector analysis. The first two Maxell equations contain the divergence of electric and magnetic fields and are usually known as "divergence equations" in which the flux of electric and magnetic fields is interpreted. The other two Maxell equations contain rotor electric and magnetic fields and are commonly referred to as the “rotor equations” that deal with the circulation of electric and magnetic fields. Equations in integral form get their transformation in differential form using the basic theorems of vector analysis and thus vector analysis, as an extremely important part of mathematical theory, is intertwined with the theory of electromagnetism, the importance of which is still widely seen in everyday life.

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The occurrence and influence of discontinuities in the rock mass on the stability of the slope above the highway

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Abstract. In the case of large projects involving the design and construction of highways, which is currently current in our country, great attention is paid to slope stability. The reason for this is that Bosnia and Herzegovina is for the most part a hilly and mountainous area, and new highways mostly pass or will pass through such areas. Precisely because of such a relief, a longer part of the highway can be on a slope, i.e. in a cut. It is necessary to ensure that the slope must be safe and stable. However, the stability and safety of the slope depend on the geomechanical characteristics of the rock mass on which the slope is located, as well as the possibility of discontinuities in it. The greater the discontinuities, the lower the quality of the rock mass. The presence of discontinuities increases the design costs, that is, the costs of ensuring slope safety. This paper will show the occurrence and impact of discontinuities in the rock mass on slope stability, as well as the impact of discontinuities on general traffic safety. Then recommendations will be given to increase the safety and stability of the slope.

1. Introduction

When talking about rock mass, its constituent parts must be mentioned, namely intact rock and discontinuities. According to ISRM (International Society for Rock Mechanics) [1] any mechanical break in the rock mass that has little or no tensile strength perpendicular to the direction of extension is considered a discontinuity. Such discontinuities include fractures and joints, faults, folds as well as planes of deposits.

The quality of the rock mass has a significant impact on the safety, costs of testing and construction of the planned facility or the protection of the facility. The stability of the slope on highways is one of the most important parameters because it can directly affect the safety and lives of people. According to Pantelidis [2], rock slopes in most road cuts, especially in mountainous areas, are subject to instability problems due to variations in rock mass conditions and external environmental factors such as seismic activity and water on slopes. Wyllie [3], believe that the material characteristics of the rock slope, the height, the angle of the face and the orientation of the rock joints play a significant role in the problem of the instability of the cut and the road slope. In addition, the stability of rock slopes can also be affected by the curvature of the highway, especially on rough terrain. Miholić [4], believes that slope stability is a complex, multivariable analysis whose results depend on slope geometry, soil and rock properties, presence of water and many other parameters. According to Berisavljević Z. and colleagues [5], anisotropy is the property of a material to have different properties in different directions. The rock mass is almost always an anisotropic material, which is a consequence of the presence of discontinuities. Yanuardian et al. [6] showed in their research that the stability of the slope

is directly dependent on the quality of the rock mass. Most of the parameters that control slope stability are related to discontinuities. The characteristics of the columnar joint play a significant role in the type of rock failure, but those of integral discontinuities additionally affect the RMR and the value of slope stability [6].

This paper will show the occurrence of discontinuities, as well as their influence on the stability of the slopes and the safety of all road users on the parts of the highway where the slopes are located. After that, measures to increase traffic safety will be proposed.

2. Appearance and influence of discontinuity

The rock mass consists of intact rock and discontinuities. Intact rock is the so-called 'clean rock', without any irregularities and deformations. However, discontinuities represent any break, that has no or deformation bearing capacity. The appearance of discontinuities is linked to the turbulent geological past when the rock was exposed to various influences such as stresses that were so great that they exceeded the strength of the rock itself. Because of this, various forms of discontinuity began to appear in the rocks, such as cracks, shear zones/faults, fractures and joints, folds and planes of deposits. All the mentioned forms of discontinuity arise as a result of different influences, i.e. stress. Cracks are the result of tensile stresses. Shear zones or faults are the results of shear stresses, as well as fractures. A set of fractures forms joints. Figure 1 shows the process of formation of discontinuities due to tensile (left) and shear (right) stresses.

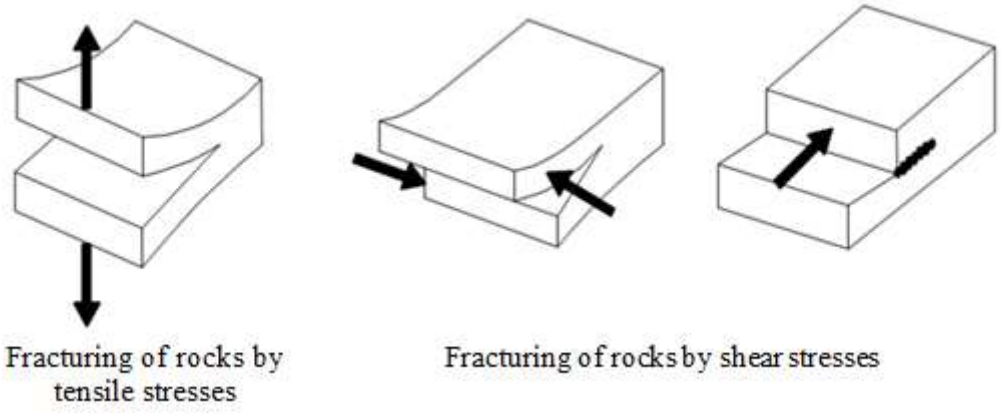

Figure 1. Formation of discontinuity [7].

What is evident is that all the hay masses are cracked to a greater or lesser extent, and this affects the deformability, strength and fracture of the rock mass, as well as the control of water permeability. In addition to these stresses, natural stresses can occur in the rock mass, which is the result of tectonic movements in the Earth's crust. When human-induced changes occur on the surface, such as surface and underground excavations, changes in primary stresses occur nearby. Such new stresses are called secondary stresses. In addition, the flow of water, within the rock mass, is related to flow through discontinuities, because the intact rock has very little porosity. An important parameter here is the amount of seepage, as well as whether the discontinuities through which the water passes are open, closed or filled. [7]

Based on the study by Yanuardian and associates [6], it was determined that integral (mechanical) discontinuities, which represent those discontinuities that have yet to develop due to rock movement and wear, have no direct influence on the type of failure and the discontinuity adjustment factor in SMR (Slope mass rating) because their orientation is still not sufficiently well developed. They found that of the other parameters, only the spacing of integral discontinuities causes a decrease in the quality of the rock mass. Therefore, further research must be carried out to understand and determine how the development of integral discontinuities can affect the stability of the rock slope.

3. Influence of discontinuity on slope stability

The stability of the slope is a basic parameter that must be met when designing buildings, both for ensuring people's lives and for investment costs during construction. The instability of the slope is observed through the mechanism of its failure. The two basic types of slope failure, which are generally accepted and described by Hoek and Brown [8], are:

a) rock mass that behaves as an equivalent continuum;
b) rock mass that behaves as a discontinuity.

This division was explained by Johansson [9], who considers that a rock that is intact or nevertheless intersected with discontinuities is a continuum. If the discontinuities are in series (two or more), then the material must be modeled as a discontinuity.

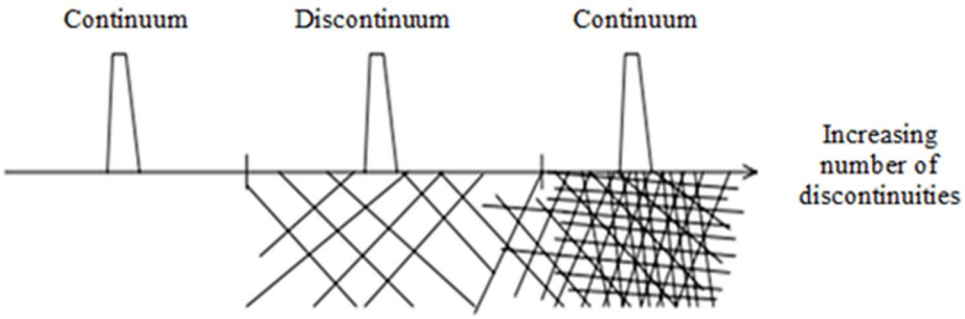

Figure 2. Consideration of rock mass by the increase of discontinuities [9].

It is generally accepted that the number of discontinuities in relation to the distance between them affects the modeling of the rock mass, i.e. the definition of continuum and discontinuity of the rock mass. This means that if there is a large number of discontinuities in the rock mass, but the distance between them is large, then such an environment is adopted as a continuum. A highly fractured rock mass, relative to a short distance, is also considered a continuum. When the ratio of the number of discontinuities and the distance between them is at a medium level, a discontinuity is adopted. This principle is explained in Figure 2. Rock masses that belong to continuum materials are generally considered isotropic or anisotropic material that are modeled according to the theory of plasticity. However, when talking about the rock mass that belongs to the discontinuity material, all properties related to strength and deformation are determined through the mechanical properties of the discontinuity. To model continuum and discontinuity, it is necessary to know: relationships between stresses and strains, failure criteria, and the parameters they include.

As discontinuities are related to shear failure, it is essential to properly assess the shear resistance in them. This assessment is quite uncertain and undefined. Factors that must be taken into account are: strength, roughness, spacing of discontinuities, occurrence of underground water, orientation that depends on the object being built, as well as filling of discontinuities. For unfilled discontinuities, 4 methods can be used to determine the shear strength:

a) The laboratory shear test is the most commonly used method. However, due to the testing of small-sized specimens and the lack of knowledge of scale effects, the determination of shear strength alone is unreliable.
b) To avoid this unreliability, the method of performing the test on a large sample on site can be used. This method is time-consuming and expensive, which does not make it the best possible choice.
c) Barton's empirical failure criterion can also be used. Then the residual friction angle φres is determined.
d) However, empirical values based on experience are often used to determine shear strength parameters. [9]

3.1. The impact of discontinuity on traffic safety

When planning roads, especially highways, where there are high speeds and a large number of users, the safety of all road users must be taken into account. When planning the highway itself, which depends mainly on the topography of the terrain, but also on the geology and geotechnical features, it is necessary to follow the contours of the terrain, to avoid large earthworks. However, if it is necessary to deviate from the rules and design a road in a larger cut, cut or embankment, it is also necessary to ensure the stability of all slopes, so that there is no collapse and loss of life for all roads users as well as workers for the construction and security of these roads.

Nengpan et al. [10] believe that large slopes affect the safety of highway construction in mountainous areas. Deformation itself, as well as breakage, occurs due to improper design. This happens because of superficially performed geotechnical investigations, which need to find out the exact properties of the soil. In addition, the instability of the slope often disrupts the plan and efficiency of construction but also affects the economic aspects of construction.

The following work will show examples of the same unstable slope over time, which was renovated, but without success.

Figure 3. Occurrence of the first landslide during construction work [11].

Figure 4. Sliding due to heavy rain [11].

Figure 5. Damage to the gabion wall [11].

Figure 6. Sliding of material [11].

Figures 3, 4, 5 and 6 show the location of the landslide on the highway and the behavior of the slope of the landslide over the years, presented by the author Mariana Cid Correia Barreira de Sousa. The first landslide occurred during the construction of the highway section when cutting the terrain. The author stated that the first slope was 1:1.5. [11]

In the following years, the slope went through a series of events that destabilized the terrain. One such example is shown in Figure 4, where a landslide occurred due to heavy rains [11]. This is the most common occurrence of landslides on slopes, primarily due to poorly performed geotechnical investigation works, which then had an impact on the way of rehabilitation and proper protection of the slope. The reason for such a landslide can also be a poorly constructed system for the drainage of atmospheric air. Unfortunately, this is a common case, especially in the Balkans.

In the same year, just a few meters away, where the gabion wall begins, a new landslide occurred, which is shown in Figure 5. The previous events were not enough of a warning, so the terrain continued to behave as it suited it best, because the gabion wall was not strong enough to stop the terrain behind from sliding. The new slippage of the material, which occurred at the top of the slope, is shown in Figure 6.

4. Recommendations for stable slopes on highways

In the previous chapter, it was possible to see how important the correct design of slope stability is. The most important factor is the safety of all road users. However, from the investor's point of view, investment costs are also very important. If the geotechnical investigations had been done well, the design of the slope stability would certainly have been much more effective. Mistakes, such as those shown in pictures 3, 4, 5 6, in addition to endangering the safety of people's lives, also led to a huge, unplanned increase in costs. In the following, successful interventions on the slope will be presented and explained, and then recommendations will be made to ensure the stability of the slope.

Figure 7. Construction of walls made of metal piles [11].

Figure 8. View of slope after interventions [11].

Subsequently, only after the first unfavorable occurrences, geotechnical investigations were carried out in order to better understand the behavior of this part of the terrain. Regarding rehabilitation and stabilization measures, the metal pile walls defined by the executive project and shown in Figure 7 were made. Figure 8 shows the slope and interventions, as well as some cracks above the impervious cover to reduce water infiltration. [11]

In order to be able to talk about the effective stability of the slope at all, before any design, it is necessary to carry out high-quality geotechnical investigation works, according to which efficient and long-term solutions for stabilization will then be developed. Groundwater is also an important parameter in the design itself, and later in the execution. It reduces normal stress. In order to limit its effect, it is necessary to reduce pore pressures, and this is achieved by draining, both surface and dug and drilled drains. Various types of support structures are also recommended, and the selection of types depends, of course, on the geotechnical characteristics of the examined terrain. The most common type are support structures with reinforcements, i.e. geotechnical anchors. Here, attention must be paid to the number and distance between the anchors, in order not to collapse, if there are discontinuities or some other irregularity in the planned distance. Retaining walls can be in the form of gabions (wire and concrete), walls made of crushed and hewn stone, concrete walls. When we talk about drains, the goal of which is to reduce pore pressure, we are talking about concrete pipes, PVC pipes and drainage pipes with a protection filter. Further analysis, design and choice of stabilization method depends on the results of geotechnical investigations.

5. Conclusion

This paper describes the appearance and influence of discontinuities that are integral parts of rock masses and significantly affect the stability of the slope. In order to obtain data on the stability of the slope, it is essential to carry out precise geotechnical investigations in order to obtain data on the number of discontinuities and the distance between them. Many projects rely on experience, because

geotechnical investigations are very expensive and increase initial investment costs. But with large objects such as the construction of highways, the execution of these works is necessary and of great importance.

The construction of highways in Bosnia and Herzegovina is a very important but demanding job. Considering that the geographic relief area is such that a good part of the highways pass through cuts, river canyons, tunnels, etc., and the occurrence of underground water should not be ruled out, it is very important to carry out geotechnical investigations, even if they increase the cost of the project as a whole.

If we take into account that all of the above, in addition to material losses due to discontinuities, or ultimately to the occurrence of landslides, can certainly lead to much more important losses, namely human lives. They should not be taken for granted, but everything necessary should be done, that is, all recommendations for slopes on highways should be taken into account in order to achieve the greatest possible safety of both road users and highway maintenance and insurance workers.

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Analysis of the bearing capacity of a reinforced concrete frame under the action of an earthquake that happened in Turkey in 2023

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Abstract. This paper presents the bearing capacity of a reinforced concrete frame of different ranges and dimensions under earthquake. The influence of reinforcement weight on resistance to seismic effects is shown. The devastating earthquake that occurred in Turkey (Hatay) in 2023 was applied in Extreme Loading for Structures (ELS) which is based on the applied element method (AEM), a derivative of the finite element method (FEM) and the discrete element method (DEM). ELS enabled the study of the behavior of the wall through the continuum phase and the discrete phase of loading, which is of great importance during the formation of cracks, the separation of blocks and finally the collapse of the structure.

1. Introduction

Computer simulation is an important key in determining the performance of structures in extreme loading conditions. However, it is not possible to predict the behavior of collapse for structures using the Finite Element Method. Reviewing the current literature, it is noticed that methods used for structural analysis are mainly based on continuum mechanics rules, like the Finite Element Method, which cannot be applied explicitly to discrete elements. Therefore continuum mechanics-based methods cannot be extended to simulate the collapse analysis. On the other hand, analysis methods based on rules of discrete elements cannot be used to predict behavior of continuum elements. As a matter of fact, structures during a collapse situation pass through the two stages: a continuum stage followed by a discrete stage. The analysis and simulation needs to follow both behavior stages in order to help in answering the following questions:

- Will the structure collapse during an extreme loading event?
- Will the collapse be partial or total?
- What is the mode of collapse of the structure?
- In cases of partial collapse, will it be possible to repair the structure?
- How long would it take for the structure to completely collapse?
- How does falling debris affect adjacent structures?
- What is the footprint affected by the collapse of a structure?

These questions are a small sample of questions that cannot be answered without having an accurate prediction of the structural performance when subjected to an extreme loading. A new method, that is capable of predicting to a high degree of accuracy the continuum and discrete behavior of structures, has been developed. Through two decades of continuous development, the Applied Element Method (AEM) was proven to be the method that can track the structural collapse behavior passing through all stages of the application of loads: elastic stage, crack initiation and propagation in ceramic materials, reinforcement and structural steel yielding, element separation, element collision (contact), and collision with the ground and with adjacent structures. The possible analysis domain of AEM in comparison to FEM is shown in figure 2. Although the FEM is accurate and reliable for analysis of continuum structures, the onset of element separation is difficult to automate and modeling of debris collision is time consuming [1].

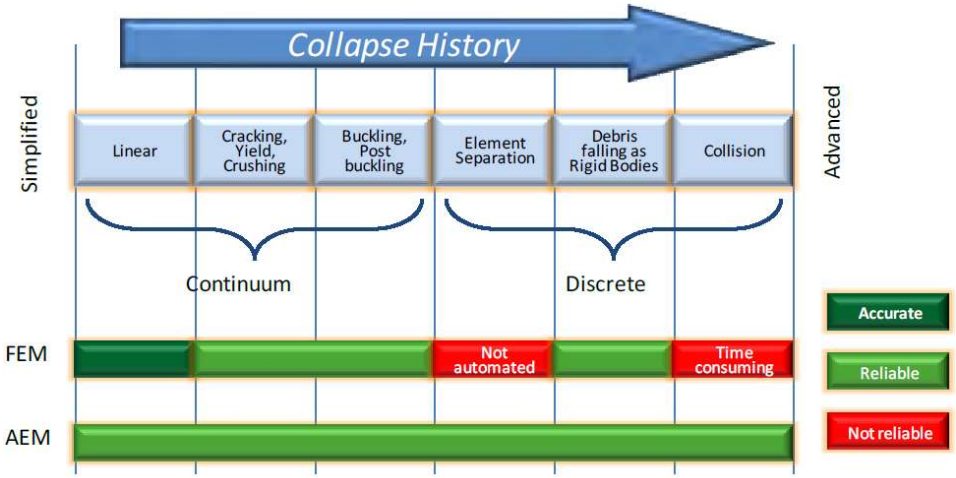

Figure 1. Analysis domain of AEM compared to FEM [1].

International publications in the area of structural engineering verify that the AEM can cover with a reasonable accuracy the fields of application. The method accuracy is compared with more than 50 experimental and theoretical results [2-6]. Literature surveys indicate that no other simulation technology has comparable overall performance to AEM. The AEM is the base method to analysis of structures under extreme loadings. Table 1 shows a brief comparison between the AEM and the FEM.

With AEM, the structure is modeled as an assembly of small elements, which are made by dividing the structure virtually, as shown in figure 2. The two elements shown in figure 2 area assumed to be connected by one normal and two shear springs located at contact points, which are distributed around the element edges. Each group of springs completely represents stresses and deformations of a certain volume as shown in figure 2.

Table 1. Comparison between AEM and FEM analysis [1].

Subject of comparison	**AEM**	**FEM**
Calculation time	Briefly	Briefly
Degrees of freedom of movement	6 per element	24 per element (8-node element)
Cracking model	Discrete (physical) cracks	Discrete cracks whose location should be predicted in advance
	No need for connecting elements	Connecting elements are needed in places of wide cracks to simulate physical cracks
	Cracks can spread at the boundaries of the elements in any direction	Cracks cannot spread from one element to another, making the structure inseparable in arbitrary locations
	Crack expansion can be monitored	The spread of cracks cannot be precisely traced.
Preprocesing time	Briefly	Long
Reinforcement	All the details of the reinforcement are taken into account, for each bar of reinforcement. For example, the diameter of the rod and the protective layer of concrete can be taken into account.	It is very difficult to accurately calculate the details of the reinforcement because the properties should be added at the locations of the integration points
Before the collapse	High precision	High precision
During and after the collapse	High precision	Inability to track the collapse of the structure

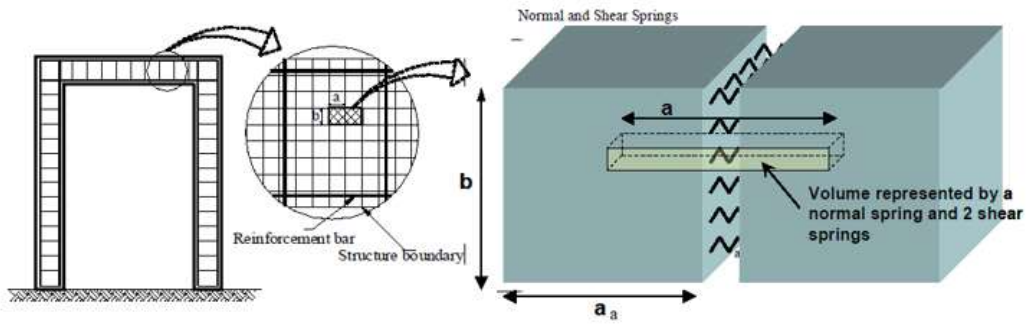

Figure 2. Modeling of the structure according to AEM [1].

2. Analysis in Extreme Loading for Structures Software

In this research, the record of the devastating earthquake with a magnitude of 7.4 on the Richter scale, which hit the southern regions of Turkey and the northern border regions of Syria at the beginning of February 6, 2023, was selected for analysis. A 26-second record with a peak ground acceleration of 8,40 m/s^2 was selected (figure 3).

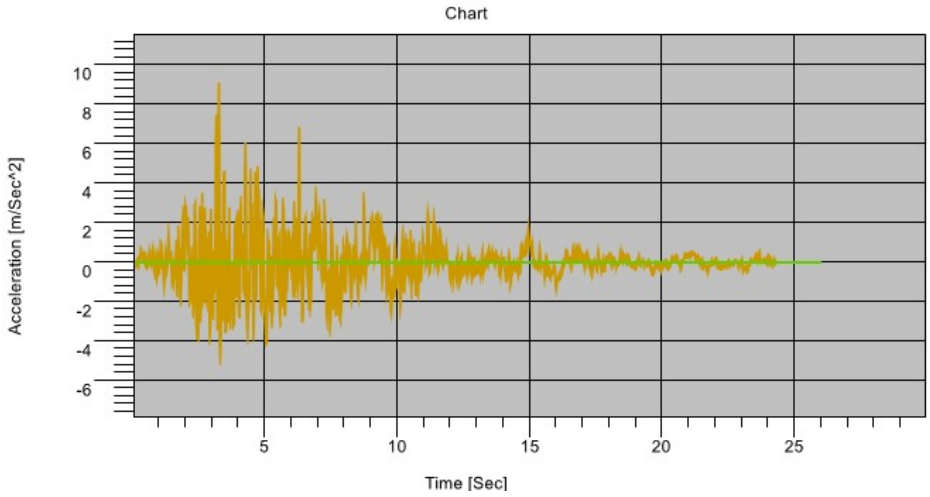

Figure 3. Part of the Hatay earthquake record [7].

Sixteen cases are modeled and analyzed in the Extreme Loading for Structures software:

- Case 1: columns with Ø8 (height 3 m) and girder with Ø8 (length 5 m)
- Case 2: columns with Ø20 (height 3 m) and girder with Ø8 (length 5 m)
- Case 3: columns with Ø8 (height 3 m) and girder with Ø14 (length 5 m)
- Case 4: columns with Ø20 (height 3 m) and girder with Ø14 (length 5 m)
- Case 5: columns with Ø8 (height 5 m) and girder with Ø8 (length 5 m)
- Case 6: columns with Ø20 (height 5 m) and girder with Ø8 (length 5 m)
- Case 7: columns with Ø8 (height 5 m) and girder with Ø14 (length 5 m)
- Case 8: columns with Ø20 (height 5 m) and girder with Ø14 (length 5 m)
- Case 9: columns with Ø8 (height 3 m) and girder with Ø8 (length 8 m)
- Case 10: columns with Ø20 (height 3 m) and girder with Ø8 (length 8 m)
- Case 11: columns with Ø8 (height 3 m) and girder with Ø14 (length 8 m)
- Case 12: columns with Ø20 (height 3 m) and girder with Ø14 (length 8 m)
- Case 13: columns with Ø8 (height 5 m) and girder with Ø8 (length 8 m)
- Case 14: columns with Ø20 (height 5 m) and girder with Ø8 (length 8 m)
- Case 15: columns with Ø8 (height 5 m) and girder with Ø14 (length 8 m)
- Case 16: columns with Ø20 (height 5 m) and girder with Ø14 (length 8 m)

Table 2. The input parameters used in the analysis.

Parameter	Value	
	Concrete	**Reinforcement**
Modulus of elasticity	26200 MPa	199947
Shear modulus	10480 MPa	79979
Separation deformation	0,1	1
Friction coefficient	0,8	0,8
Specific weight	2500 kg/m^3	7840
External damping coefficient	0	0
Normal contact stiffness factor	0,0001	0,0001
Shear contact stiffness factor	0,00001	0,00001
Stiffness factor when unloading the contact spring	2	2
Stiffness factor when unloading the contact spring	0,0000145	0,000013
Tensile strength	2,94 MPa	
Compressive strength	29,40 MPa	
Yield Stress	-	353 MPa
Ultimate Strain	-	0,15
Post Yield Stiffness Ratio	-	0,01
Ultimate/Yield Stress Ratio	-	1,4
Minimum normal stiffness factor	0,01 MPa	
Minimum shear stiffness factor	0,01 MPa	
Shear strength	7,35 MPa	
Residual shear strength factor	1	
Failure Softening Factor	-	0,1
Shear Stress Weight	-	1
Poisson's ratio	0	0

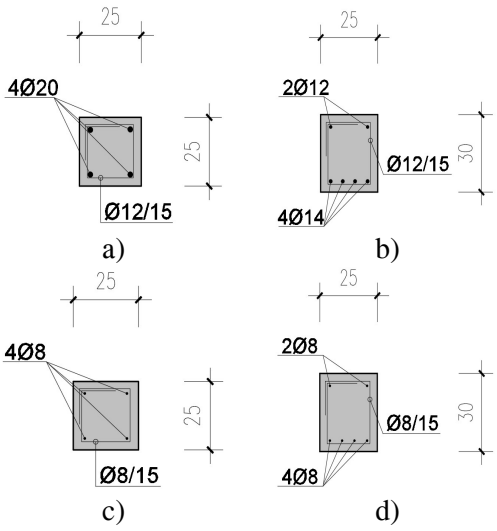

Figure 8. Cross section of: a) column for cases 1, 3, 5, 7, 9, 11, 13 and 15; b) girder for cases 1, 3, 5, 7, 9, 11, 13 and 15; c) column for cases 2, 4, 6, 8, 10, 12, 14 and 16; d) girder for cases 2, 4, 6, 8, 10, 12, 14 and 16.

2.1. Case 1: columns with Ø10 (height 3 m) and girder with Ø8 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,85 MPa, minimum stress was -0,18 MPa and maximum displacement of 0,0048 m. The figure 4 shows the principal stresses and displacements in the fifth second of the earthquake duration.

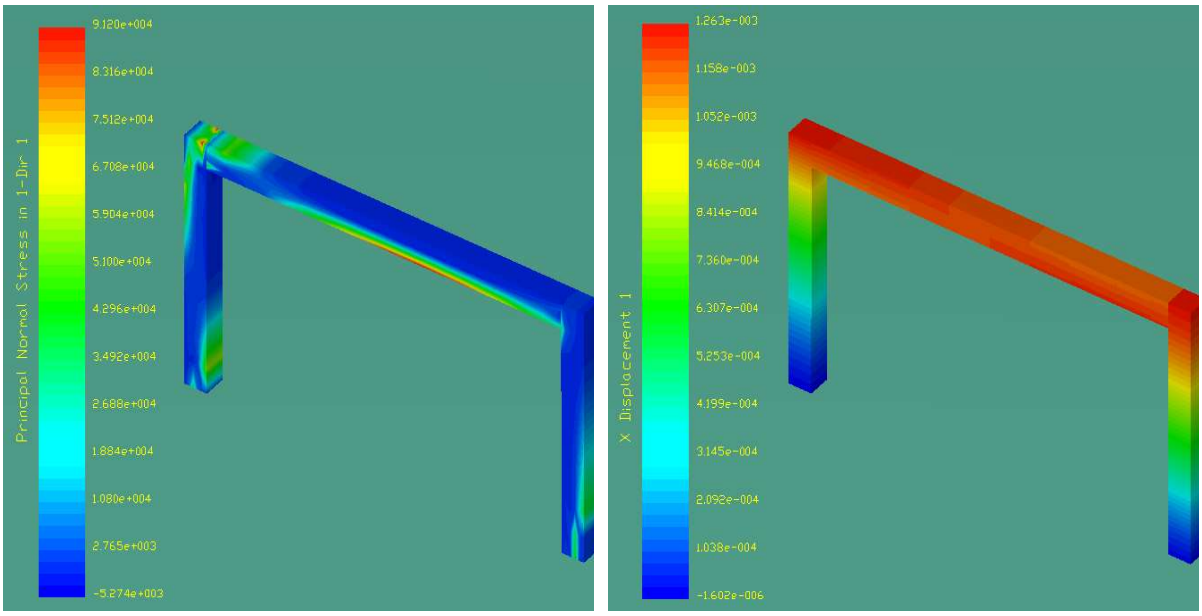

Figure 4. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.2. Case 2: columns with Ø20 (height 3 m) and girder with Ø8 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,60 MPa, minimum stress was -0,15 MPa and maximum displacement of 0,0023 m. The figure 5 shows the principal stresses and displacements in the fifth second of the earthquake duration.

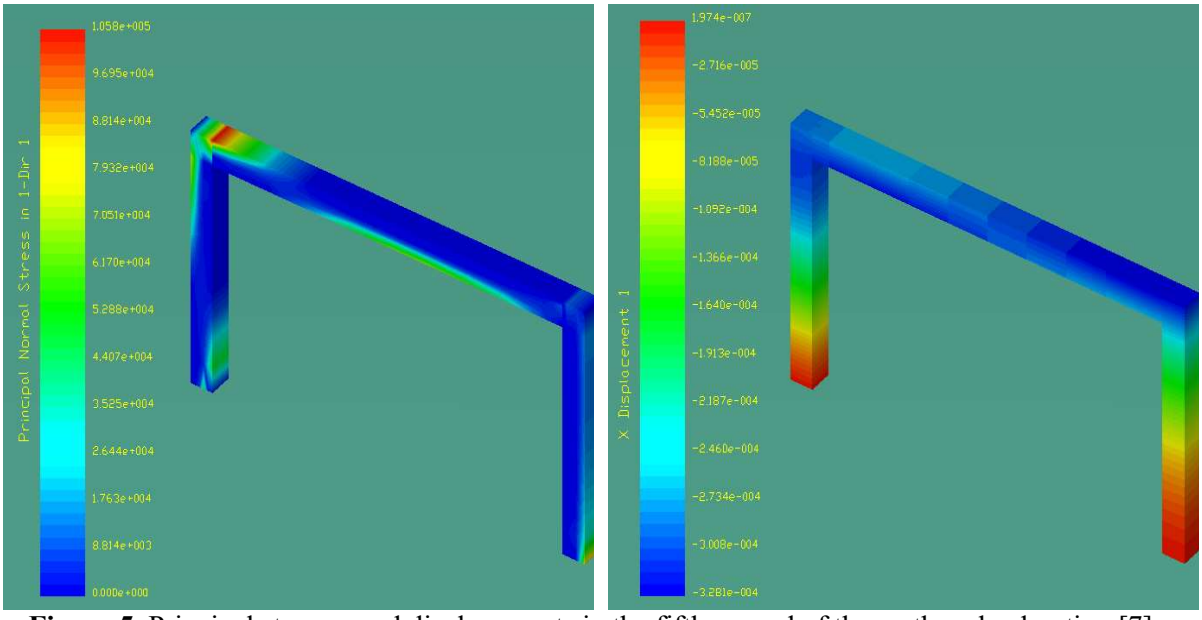

Figure 5. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.3. Case 3: columns with Ø10 (height 3 m) and girder with Ø14 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,74 MPa, minimum stress was -0,12 MPa and maximum displacement of 0,0038 m. The figure 6 shows the principal stresses and displacements in the fifth second of the earthquake duration.

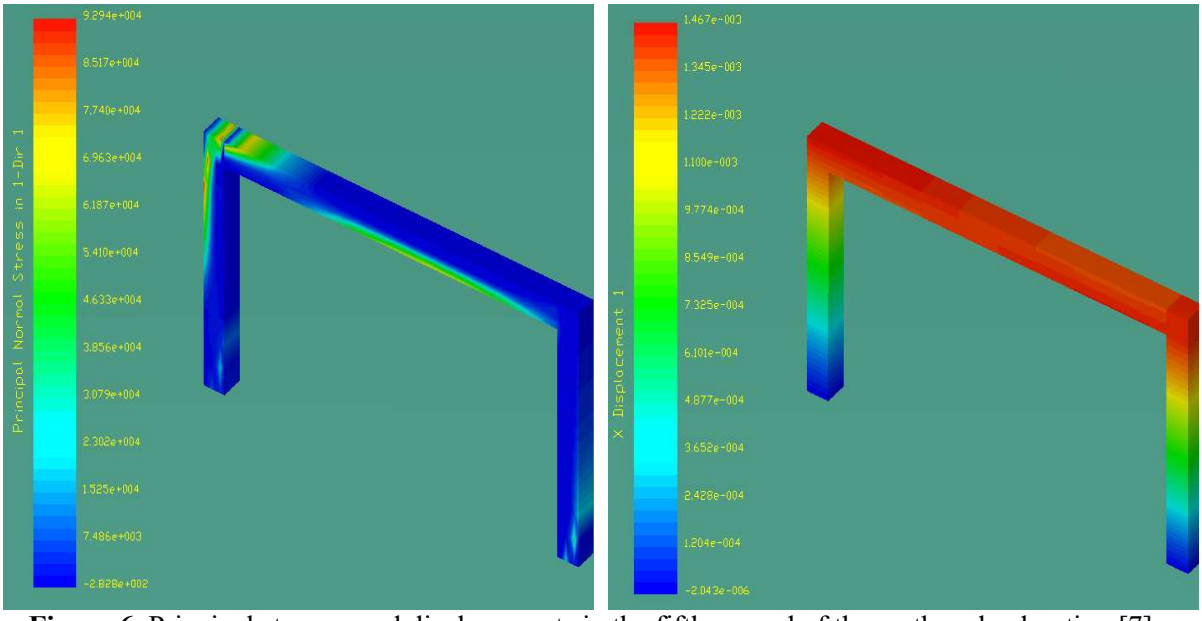

Figure 6. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.4. Case 4: columns with Ø20 (height 3 m) and girder with Ø14 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 3,82 MPa, minimum stress was -0,00007 MPa and maximum displacement of 0,0020 m. The figure 7 shows the principal stresses and displacements in the fifth second of the earthquake duration.

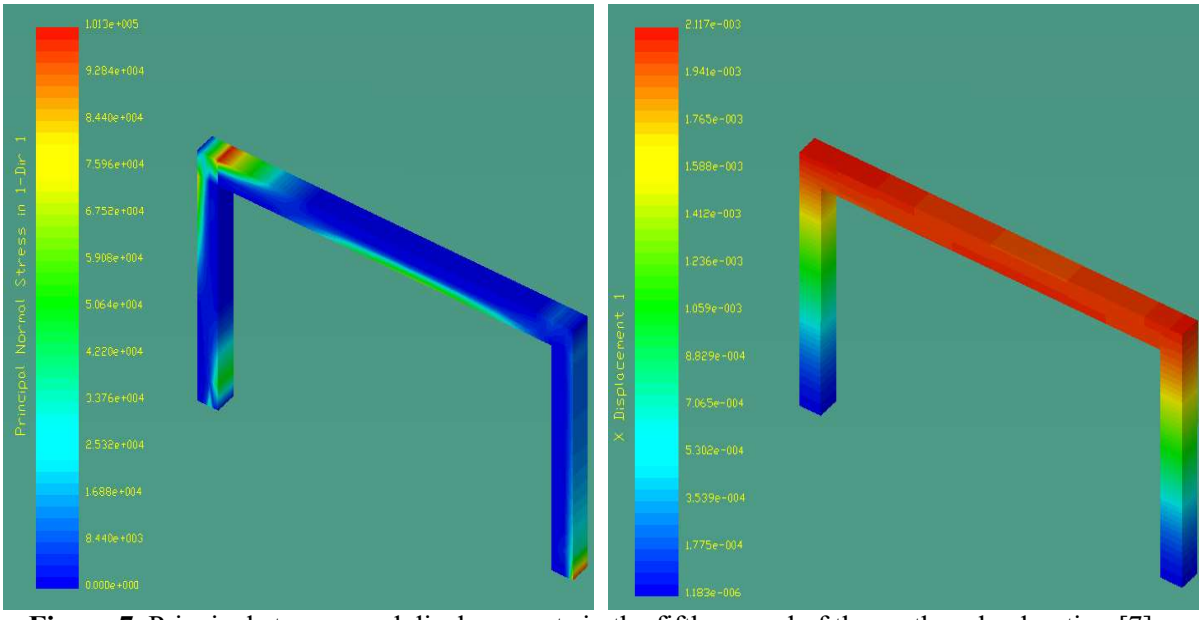

Figure 7. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.5. Case 5: columns with Ø10 (height 5 m) and girder with Ø8 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,53 MPa, minimum stress was -0,16 MPa and maximum displacement of 0,023 m. The figure 8 shows the principal stresses and displacements in the fifth second of the earthquake duration.

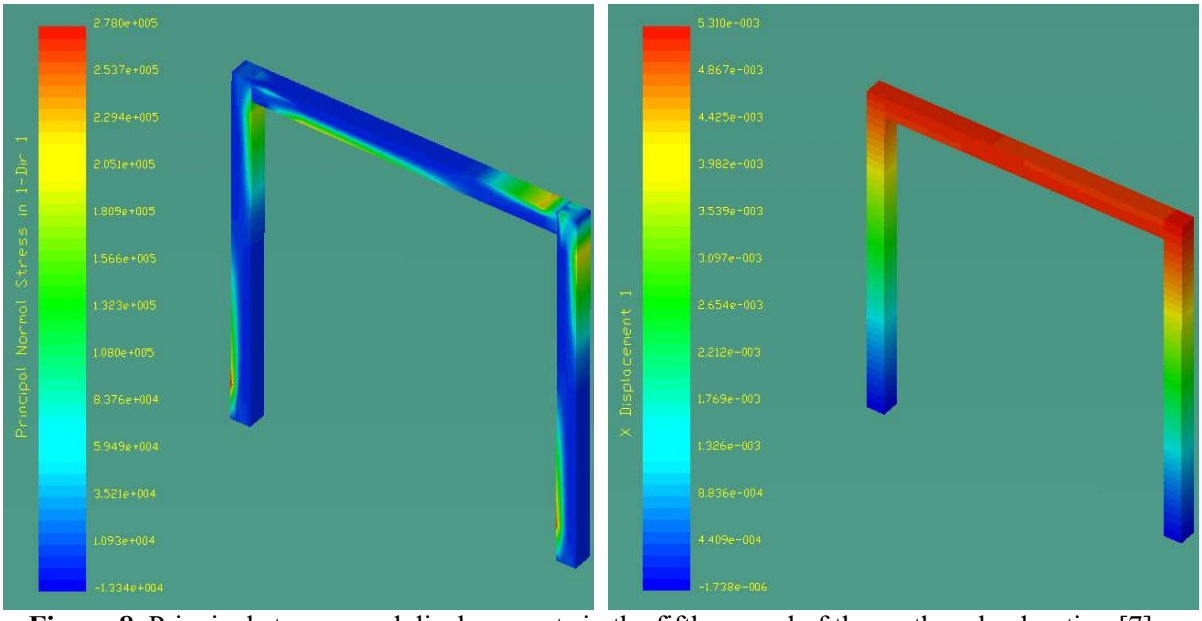

Figure 8. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.6. Case 6: columns with Ø20 (height 5 m) and girder with Ø8 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,29 MPa, minimum stress was -0,26 MPa and maximum displacement of 0,019 m. The figure 9 shows the principal stresses and displacements in the fifth second of the earthquake duration.

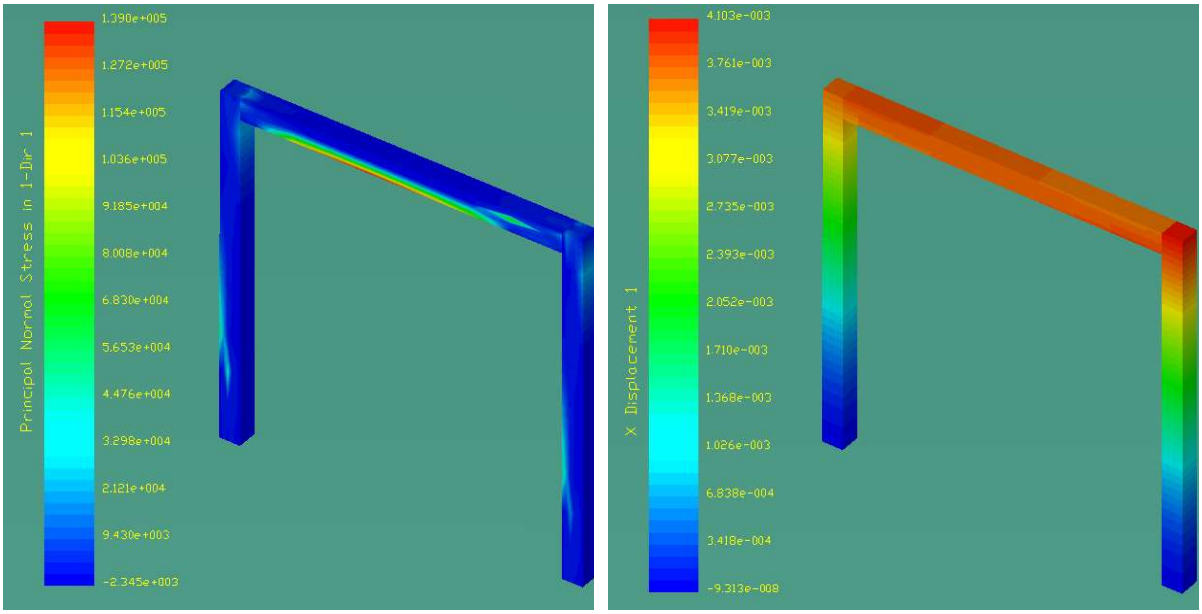

Figure 9. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.7. Case 7: columns with Ø10 (height 5 m) and girder with Ø14 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,39 MPa, minimum stress was -0,23 MPa and maximum displacement of 0,021 m. The figure 10 shows the principal stresses and displacements in the fifth second of the earthquake duration.

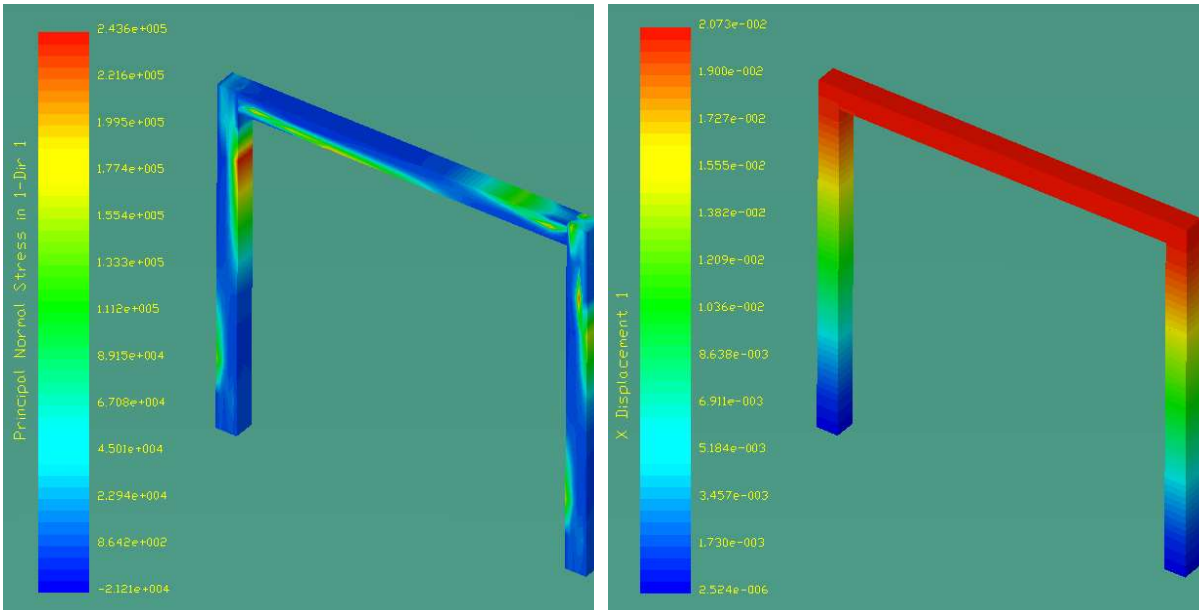

Figure 10. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.8. Case 8: columns with Ø20 (height 5 m) and girder with Ø14 (length 5 m)

During the earthquake, the frame didn't collapse. The maximum stress was 6,31 MPa, minimum stress was -0,16 MPa and maximum displacement of 0,017 m. The figure 11 shows the principal stresses and displacements in the fifth second of the earthquake duration.

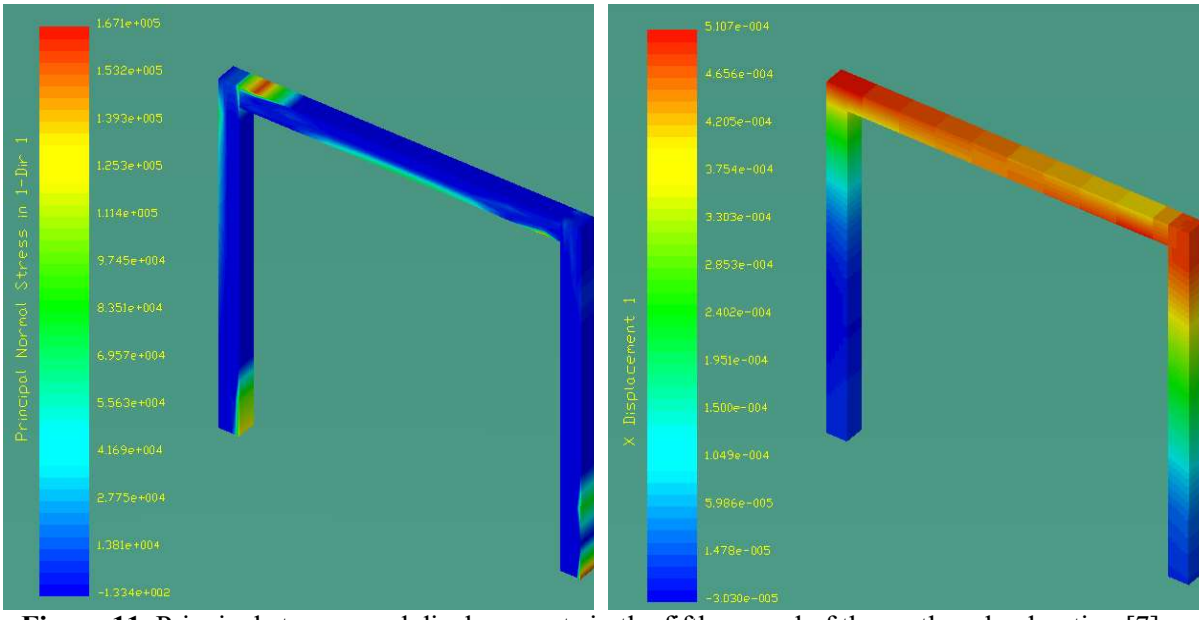

Figure 11. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.9. Case 9: columns with Ø10 (height 3 m) and girder with Ø8 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 5,60 MPa, minimum stress was -0,68 MPa and maximum displacement of 0,018 m. The figure 12 shows the principal stresses and displacements in the fifth second of the earthquake duration.

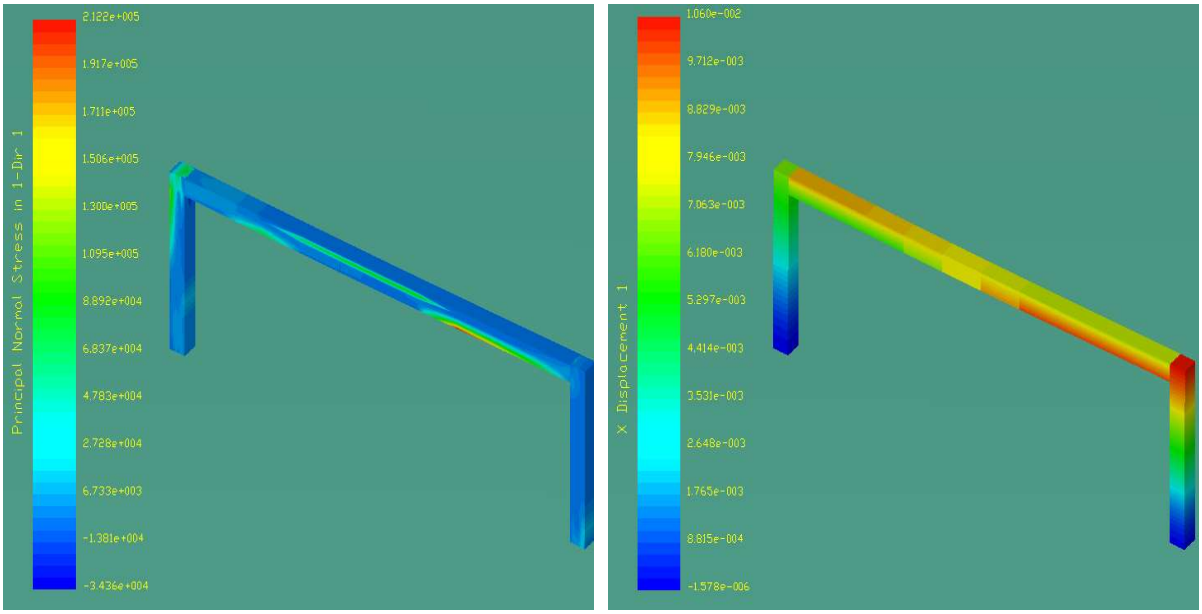

Figure 12. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.10. Case 10: columns with Ø20 (height 3 m) and girder with Ø8 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 5,76 MPa, minimum stress was -0,49 MPa and maximum displacement of 0,010 m. The figure 13 shows the principal stresses and displacements in the fifth second of the earthquake duration.

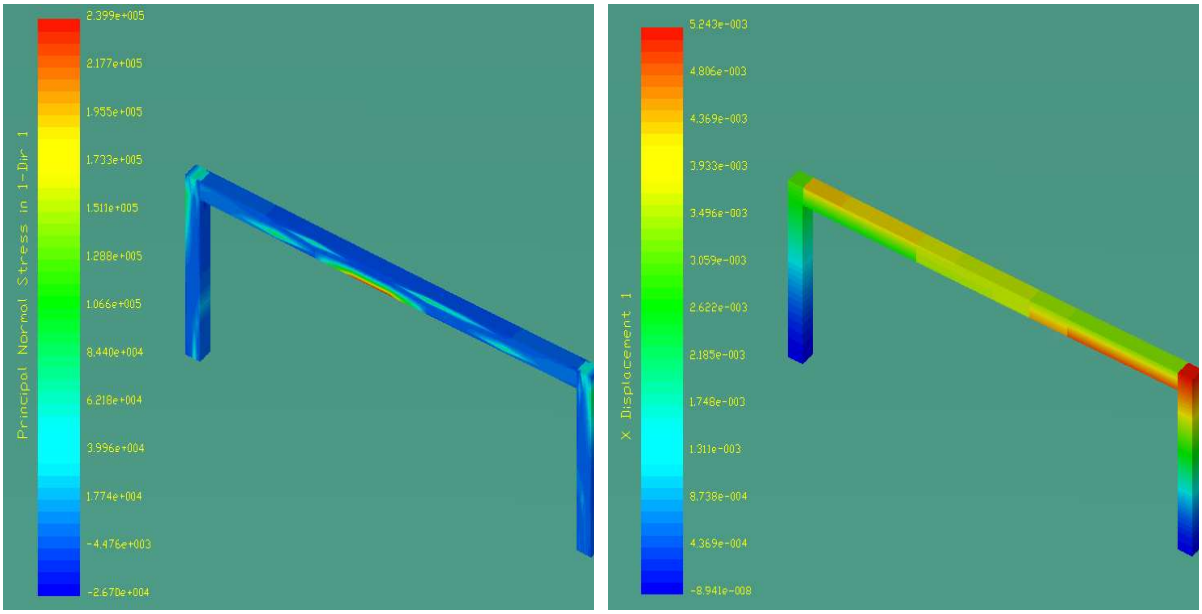

Figure 13. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.11. Case 11: columns with Ø10 (height 3 m) and girder with Ø14 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 6,09 MPa, minimum stress was -0,70 MPa and maximum displacement of 0,012 m. The figure 14 shows the principal stresses and displacements in the fifth second of the earthquake duration.

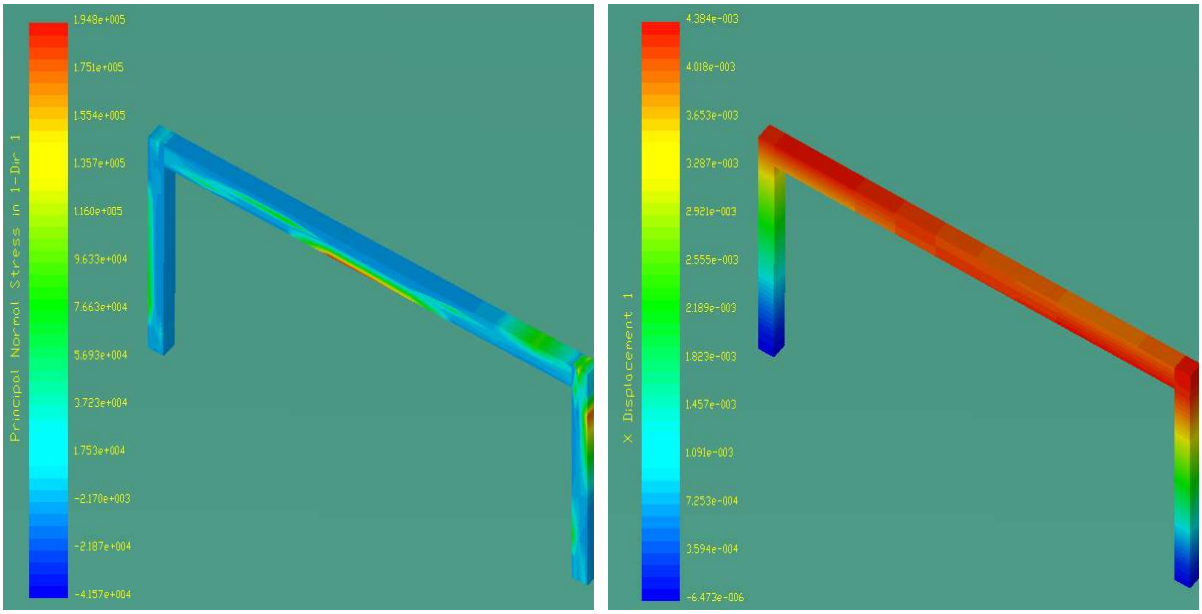

Figure 14. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.12. Case 12: columns with Ø20 (height 3 m) and girder with Ø14 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 5,11 MPa, minimum stress was -0,55 MPa and maximum displacement of 0,008 m. The figure 15 shows the principal stresses and displacements in the fifth second of the earthquake duration.

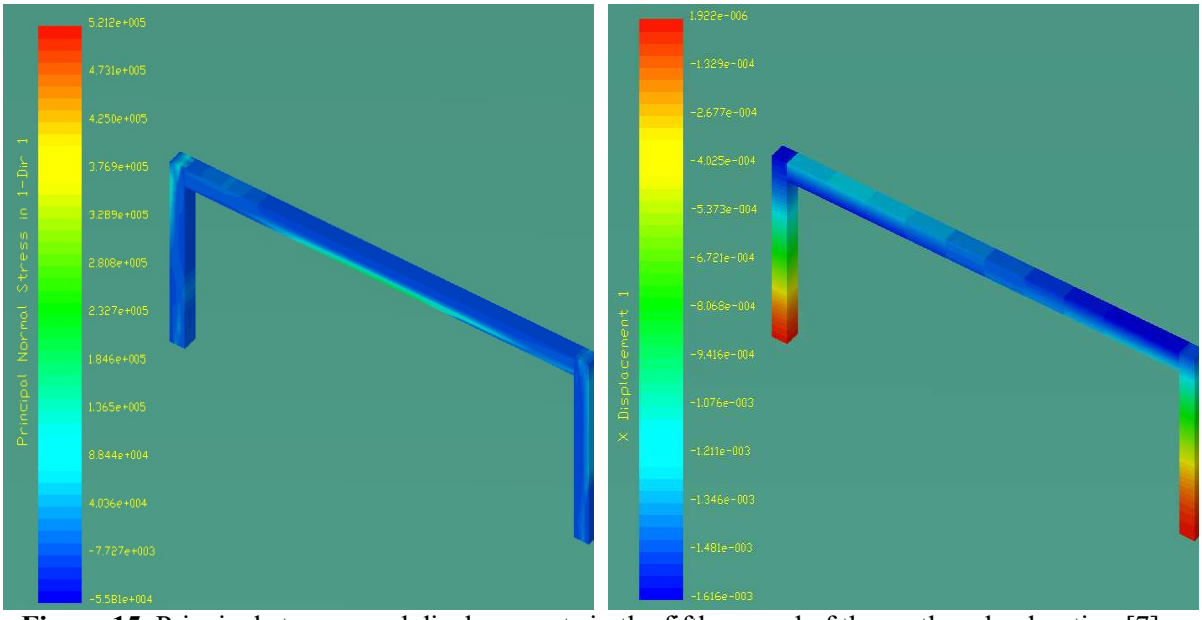

Figure 15. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.13. Case 13: columns with Ø10 (height 5 m) and girder with Ø8 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,12 MPa, minimum stress was -0,15 MPa and maximum displacement of 0,037 m. The figure 16 shows the principal stresses and displacements in the fifth second of the earthquake duration.

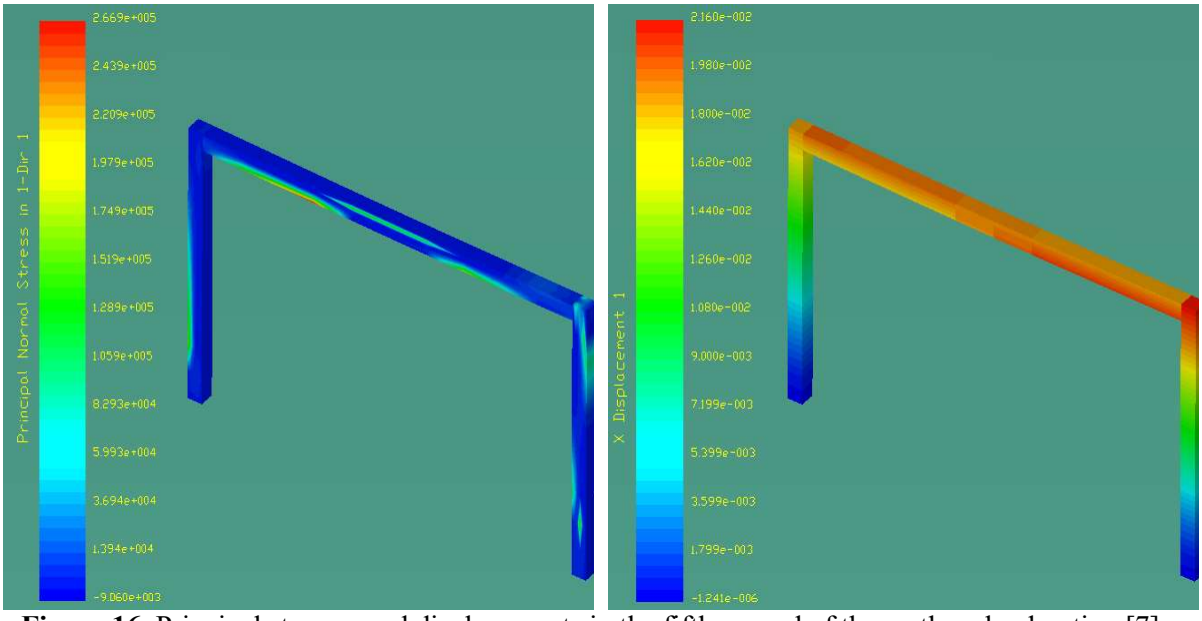

Figure 16. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.14. Case 14: columns with Ø20 (height 5 m) and girder with Ø8 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,68 MPa, minimum stress was -0,15 MPa and maximum displacement of 0,024 m. The figure 17 shows the principal stresses and displacements in the fifth second of the earthquake duration.

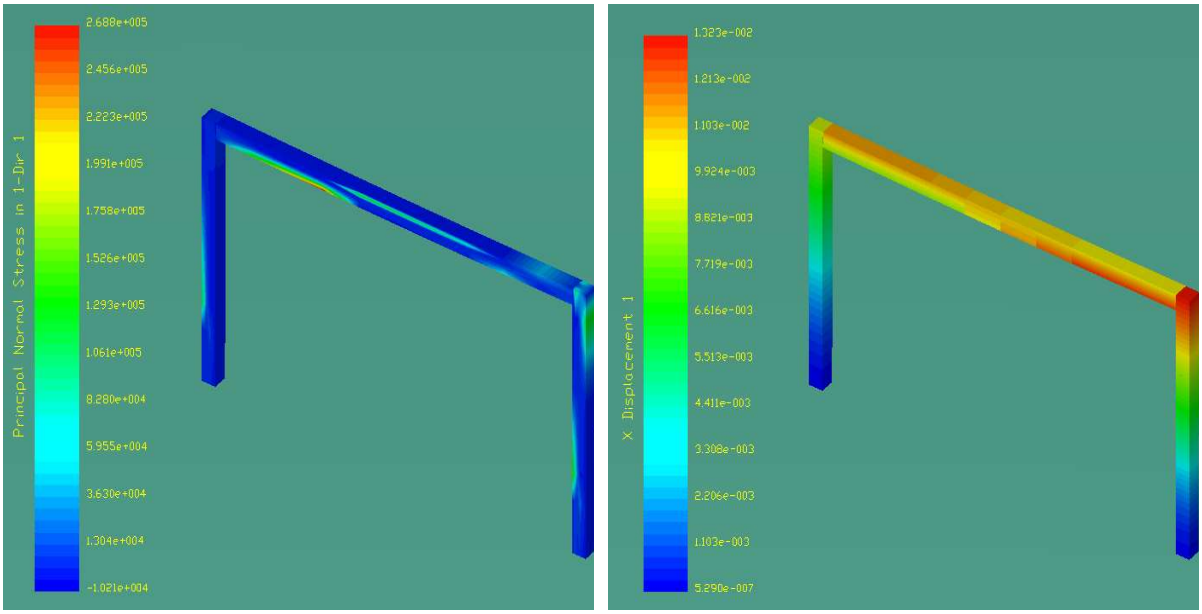

Figure 17. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.15. Case 15: columns with Ø10 (height 5 m) and girder with Ø14 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,17 MPa, minimum stress was -0,26 MPa and maximum displacement of 0,028 m. The figure 18 shows the principal stresses and displacements in the fifth second of the earthquake duration.

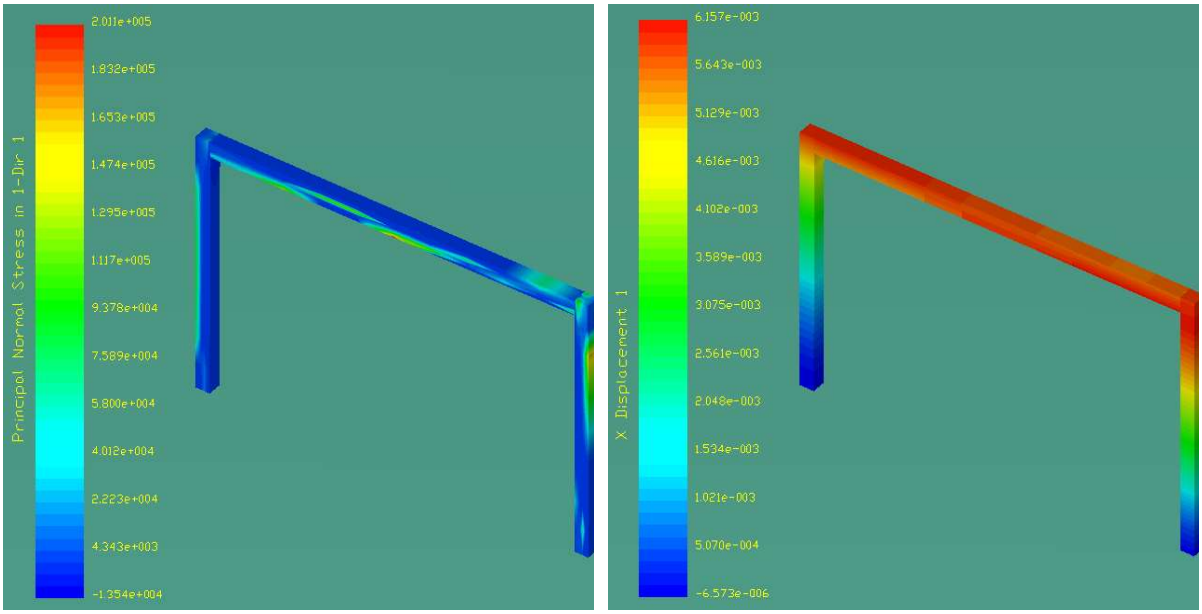

Figure 18. Principal stresses and displacements in the fifth second of the earthquake duration [7].

2.16. Case 16: columns with Ø20 (height 5 m) and girder with Ø14 (length 8 m)

During the earthquake, the frame didn't collapse. The maximum stress was 4,29 MPa, minimum stress was -0,31 MPa and maximum displacement of 0,022 m. The figure 19 shows the principal stresses and displacements in the fifth second of the earthquake duration.

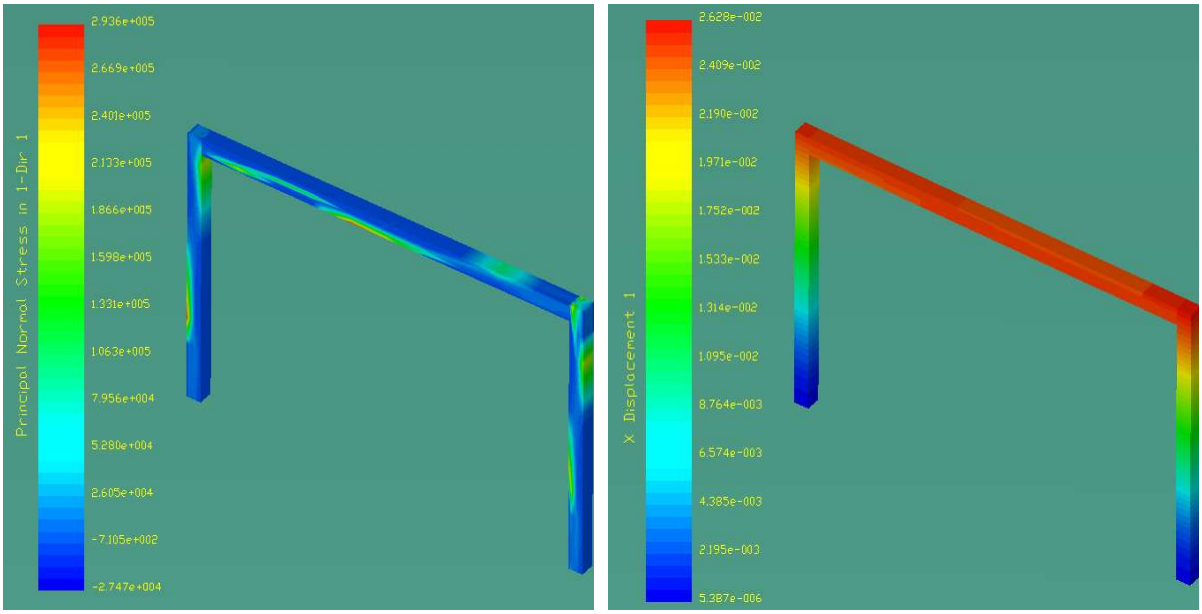

Figure 19. Principal stresses and displacements in the fifth second of the earthquake duration [7].

3. Conclusion

In this paper, it is shown how displacements and stresses decrease with an increase in the weight of the reinforcement. The maximum displacement is obtained for case 13 and has a value of 3.7 cm, while the smallest displacement is obtained for case 4 and has a value of 0.002. For the same dimensions of the frame, for the case with a higher weight of reinforcement, the displacements are smaller by about 2.4 times. Table 3 shows the maximum and minimum principal stresses, as well as the maximum displacements.

Table 3. Results from the analysis

	Maximum stress [MPa]	Minimum stress [MPa]	Maximum displacement [m]
Case 1	4,85	-0,18	0,0048
Case 2	4,60	-0,15	0,0023
Case 3	4,74	-0,12	0,0038
Case 4	3,82	-0,00007	0,0020
Case 5	4,53	-0,16	0,023
Case 6	4,29	-0,26	0,019
Case 7	4,39	-0,23	0,021
Case 8	6,31	-0,16	0,017
Case 9	5,60	-0,68	0,018
Case 10	5,76	-0,49	0,010
Case 11	6,09	-0,70	0,012
Case 12	5,11	-0,55	0,008
Case 13	4,12	-0,15	0,037
Case 14	4,68	-0,15	0,024
Case 15	4,17	-0,26	0,028
Case 16	4,29	-0,31	0,022

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Passive house, principles of design and construction

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Abstract. The term "Passive house" was mentioned for the first time in the 90s in Germany, when the first house was built with significantly less heat required for heating compared to standard houses. This type of building consumed less than 12 kWh/m^2 of heating energy per year. A passive house is considered to be any house that consumes less than 15 kWh/m^2 of space heating energy on an annual basis. In order to achieve this, already in the design phase, certain principles must be met, such as; compactness of the building, southern orientation of the building, avoidance of more complex forms of construction, super insulation, avoidance of thermal bridges, ventilation heat recovery, windows Uw = <0.8 W/m^{2}K, impermeability of the building, etc. The design of passive houses is significantly different from classic houses. After applying all the above-mentioned principles, data entry into the PHPP software is accessed, which gives us the annual energy consumption for heating per square meter of the building as an output. PHPP (Passive House Planning Package) is an energy efficiency planning tool based on the MS Excel package. This paper will present an example of a family house project with the application of all the principles mentioned above, as well as the results shown in the PHPP software.

1. Introduction

The average annual energy consumption in a Bosnian household is around 7900 kWh. The reasons for such high consumption lie in the fact that the largest number of buildings were built in the 70s and 80s, before adapting regulations on mandatory thermal protection. In addition, there is the wrong orientation of the building, insufficient insulation of the building, poor quality of windows and much more.

The main goal of passive construction is maximum comfort while minimizing energy consumption. Already in the early stages of designing a passive house, it is necessary to take into account the shape of the house, the orientation towards the sides of the world, the conditions of the location, the size and position of windows and doors, protection from the sun, etc. The costs of building a passive house are on average about 15% higher than the construction of a normal house, however, in a few years the price of the investment is amortized through lower energy bills.

2. Passive house, principles

The main goal in building passive houses is to save energy. The annual energy consumption of a passive house for heating is less than 15 kWh/m^2. For comparison, a low-energy house has a

consumption of about 35 kWh/m^2, and a classic house (well insulated) has an annual energy consumption of about 130 kWh/m^2[1].

In order for a building to be considered passive, it must meet the following conditions:

- the maximum energy consumption for heating per square meter of net living space must be 15 kWh,
- the total energy used for heating, hot water and electricity must not exceed 60 kWh per square meter of treated floor area per year,
- thermal comfort must be satisfied for all living spaces during the winter and summer months, with no more than 10% of hours in a given year above 25°C [2].

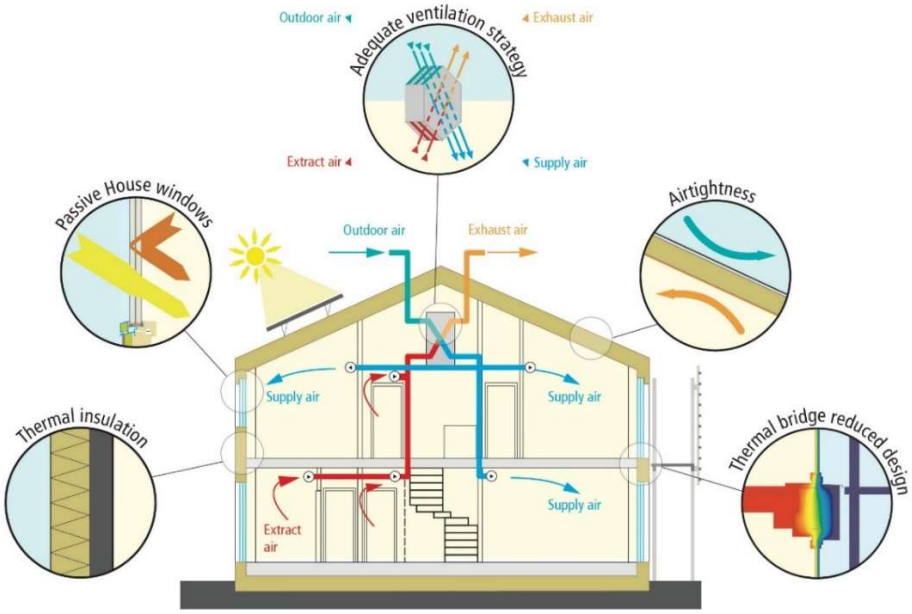

Figure 1. Passive house principles [3].

The following principles apply to the construction of a passive house:

- the outer envelope of the house must be very well insulated. The recommended heat transfer coefficient (U-value) through the outer wall is 0.15 W/(m^{2}K),
- window frames must be well insulated and equipped with low-emission glasses filled with argon or krypton. The implied heat transfer coefficient is 0.80 W/(m^{2}K),
- efficient ventilation and quality indoor air are key. At least 75% of the heat from the exhaust air is re-transferred to the fresh air using a heat exchanger,
- uncontrolled leakage through gaps must be less than 0.6 of the total volume of the house per hour during the pressure test at 50 Pa,
- thermal bridges must be avoided as much as possible at all connections [3].

3. Passive house project

The basic idea of a passive house is to minimize the need for heating in order to ensure the required amount of heat for heating the building space by simply heating the fresh air that heats the space. Taking into account the temperature of the outside air, i.e. the air entering the room, the specific heat capacity of the air, and the maximum temperature to which the air may be heated in order to make the room comfortable, the PHPP software calculated the maximum amount of heat required for heating of 15 kWh/ m^{2}a.

3.1. Certification of passive house

The Passive House Planning Package (PHPP) is a special building physics calculation tool developed for passive houses by the Passive House Institute in Darmstadt. It is made in the form of an Excel table, and is based mainly on calculations prescribed by valid European standards, so it is also applicable to ordinary buildings, and not exclusively to passive houses. It is recognized as the best indicator of the correctness of the project solution of a passive house in terms of energy characteristics [4].

3.2. Analysis of the technical characteristics of the project

The subject of this paper is the main project for the construction of a family house. Below is a short technical description of the project. The house consists of the ground floor and first floor. The load-bearing structure consists of concrete foundations and block brick walls. The ceiling slab above the ground floor is made of reinforced concrete. The roof is designed as a flat green roof. The outer walls are designed as so-called ECOSE system (phenol and formaldehyde-free binder technology) with stone wool thermal insulation and brick finish. External windows are made of wood-aluminum profiles with triple glazing. Protection from the sun is provided by external blinds. Extruded polystyrene (XPS) is placed under the concrete floor slab.

The mechanical ventilation unit for heat recovery is a Zehnder, ComfoAir Q350, with a heat recovery coefficient of 82.4% and an energy consumption at 100 Pa of 0.29 Wh/m^3. The unit is intended to be located in the pantry and serve the entire house.

An air/water heat pump is provided for heating. The external module is placed outside the building, and the internal module in the storage room. The connection between these two modules is made with insulated copper pipes. The heat pump is combined with a hot water tank and a floor heating system.

All these measures related to mechanical installations were not taken into account because the primary goal of this work is to solve the problem of passive house from the construction aspect.

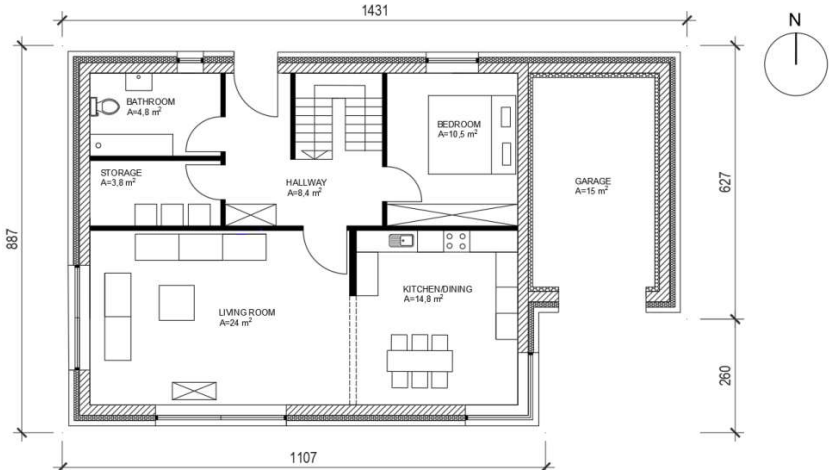

Figure 2. Floor plan of the ground floor with the net areas of the rooms [5].

In a functional sense, this building is a residential building with P+1 floors intended for family housing. The ground floor is intended for living - common rooms of family members. It consists of a living room, a kitchen with a dining room, a bedroom, a bathroom, a storage room and a hallway. The area of the ground floor is 66.30 m^2. On the ground floor there is also a garage of 15 m^2.

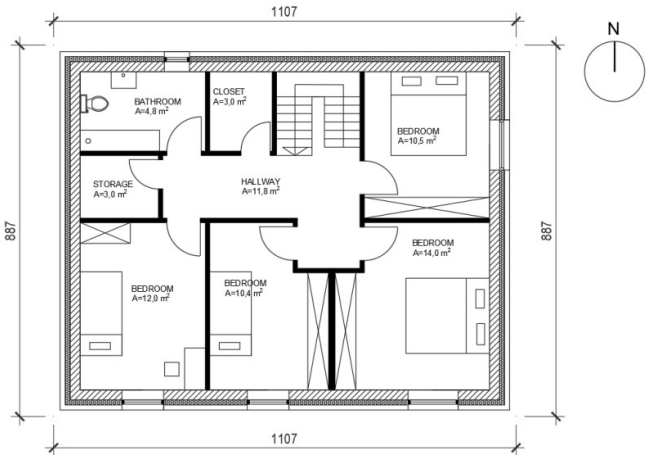

Figure 3. Floor plan with the net areas of the rooms [5].

There are two bedrooms and two children's rooms on the first floor and they are perfectly exposed to the surrounding landscape. The first floor also consists of a bathroom, a storage room and a wardrobe. The floor area is 66.30 m^2.

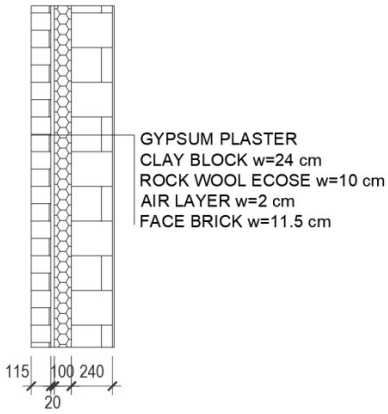

Figure 4. Detail of the external wall composition [5].

Table 1 shows the layers of the outer wall, which can be seen in the first column. The second column shows the heat transfer coefficients (λ), and the third column shows the thickness of each of the layers. The PHPP tool automatically outputs the U-value after we enter the data in these three mentioned columns.

Table 1. Review of the heat transfer coefficient for the external wall [6].

1	EXTERNAL WALL					
Assembly No.	Building Assembly Description					
	Heat Transfer Resistance [m²K/W]	interior R_{si}:	0,13			
		exterior R_{se}:	0,04			
	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Gypsum plaster	1,000					15
2.	Clay block	0,080					240
3.	Rock wool ECOSE	0,032					100
4.	Air layer	0,070					10
5.	Face brick	0,680					115
6.							
7.							
8.							
			Percentage of Sec. 2		Percentage of Sec. 3		Total
							48,0 cm
			U-Value:	0,151	W/(m²K)		

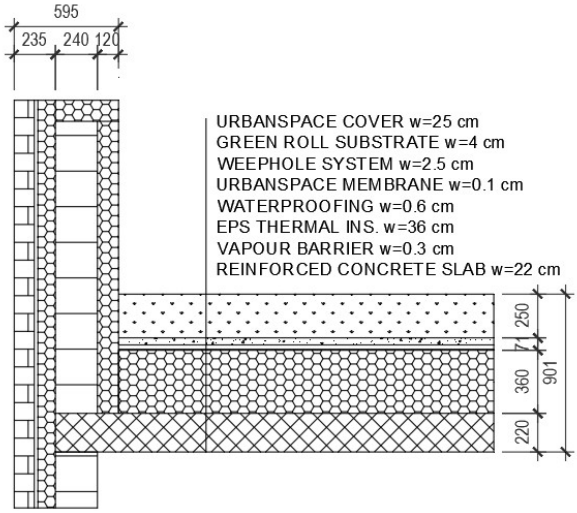

Figure 5. Detail of the composition of the flat roof [5].

Table 2 shows the layers of a flat roof with Urbanspace covering. The total thickness of the flat roof is 90.5 cm. The calculation showed that the total heat transfer coefficient for this element is 0.095 W/(m^{2}K).

Table 2. Review of the heat transfer coefficient for a flat roof [6].

2	ROOF					
Assembly No.	Building Assembly Description					
	Heat Transfer Resistance [m²K/W]	interior R_{si}:	0,10			
		exterior R_{se}:	0,04			
	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Reinforced concr.slab	2,300					220
2.	Vapour barrier	0,230					3
3.	EPS thermalins.	0,035					360
4.	Waterproofing	0,230					6
5.	Urbanscape membrane	0,230					1
6.	Weephole system						25
7.	Green Roll substrate						40
8.	Urbanscape cover						250
				Percentage of Sec. 2		Percentage of Sec. 3	Total
							90,5 cm
				U-Value:	0,095	W/(m²K)	

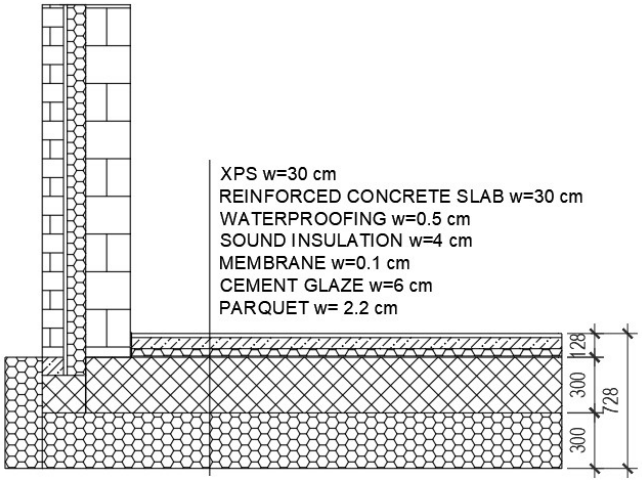

Figure 6. Detail of the floor composition [5].

Table 3 shows the layers of the floor on the ground. The total thickness is 72.8 cm. The calculation showed that the total heat transfer coefficient for this element is 0.107 W/(m^{2}K).

Table 3. Review of the heat transfer coefficient for the floor [6].

3	FLOOR					
Assembly No.	Building Assembly Description					
	Heat Transfer Resistance [m²K/W]	interior R_{si}:	0,17			
		exterior Rse:	0,00			
	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Parquet	0,200					22
2.	Cement glaze	1,400					60
3.	Membrane	0,700					1
4.	Sound insulation	0,040					40
5.	Waterproofing	0,170					5
6.	Reinforced concr.slab	2,300					300
7.	XPS	0,038					300
8.							
			Percentage of Sec. 2		Percentage of Sec. 3		Total
							72,8 cm
			U-Value:	0,107	W/(m²K)		

Specific Demands with Reference to the Treated Floor Area				
Treated Floor Area:	156,0 m²			
	Applied:	Monthly Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	15	kWh/(m²a)	15 kWh/(m²a)	Yes
Pressurization Test Result:	0,2	h^{-1}	0,6 h^{-1}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	65	kWh/(m²a)	120 kWh/(m²a)	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	37	kWh/(m²a)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:		kWh/(m²a)		
Heating Load:	10	W/m²		
Frequency of Overheating:	3	%	over 25 °C	
Specific Useful Cooling Energy Demand:		kWh/(m²a)	15 kWh/(m²a)	
Cooling Load:	9	W/m²		

Figure 7. PHPP certificate [6].

In Figure 7 we can see what a PHPP certificate looks like. This passive house planning package provides reliable results for the following data:

- need for heating per year (kWh/m^{2}a),
- annual demand for renewable primary energy (kWh/m^{2}a),
- heating load (W/m^2),
- summer comfort in case of passive cooling: frequency of overheating (%),
- cooling load (W/m^2),
- air pressure (h^{-1}).

As we said, the maximum annual energy consumption for heating must be 15 (kWh/m^{2}a). From the attached certificate, we can see that this condition is met.

Heating and cooling loads actually tell us how much energy is used per square meter of the building for heating and cooling.

The quality of housing is also influenced by good thermal insulation, which contributes to the building's thermal comfort and thus prevents overheating, which is highly undesirable in passive houses.

As for air pressure, the house must not leak air more than 0.6 times the volume of the house per hour, at a tested pressure of 50 Pa.

4. Conclusion

In order to get an optimal and energy-efficient house, it is necessary to anticipate certain decisions with your designer already in the conceptual design phase. You need:

- analyze the location, orientation and shape of the house,
- insulate the outer envelope of the house with a high level of thermal insulation,
- avoid thermal bridges,
- make the most of heat gains from the Sun,
- protect the house from excessive sunlight,
- use an energy-efficient heating, cooling and ventilation system.

All these requirements need to be considered in detail and the best variant must be found in order for the passive object to show the best energy characteristics. Such an idea was given in this paper, where we could see what a passive house certification looks like using the PHPP tool. In order for the PHPP tool to release the maximum required amount of heat for heating, we need to enter the layers of building elements and their U-values, the temperature inside the house, as well as the dimensions and location of the windows. In tables 1., 2. and 3. we saw the U-values for the mentioned layers of building elements and the calculation in the PHPP software showed that the required amount of heat for heating is 15 kWh/m^{2}a, which meets the requirements of a passive house. Of course, these results can be much better, primarily by improving machine installations. Here, among other things, we mean the ventilation system, which plays a key role because it ensures clean air and eliminates humidity and odors that can occur in the outside air. In order for the ventilation system to function, it is necessary to install a recovery unit, the task of which is to collect the warm air in the building in one place and transfer it to the fresh air entering the building. In this way, we drastically reduce the need for active heating. To heat the water for the shower, we can use various combinations from electric heaters in the water heater, gas water heaters, solar panels, solid fuel boilers, all the way to heat pumps (heat pumps). Most often, heat pumps are used, which enable the transfer of thermal energy from the ground, water or air to the central heating system. This energy is used to heat the water in the water heater and the water in the underfloor heating.

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Introduction to OpenFOAM trough wind load analysis on a steel hall

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Abstract. There exists a large number of commercial software available on the market used for numerical simulations using various methods. The paper presents the software OpenFOAM, which is unlike commercial software, free and open-source. The advantage of open-source software is that it offers complete control over the simulation but requires greater technical knowledge. The paper demonstrates the capabilities of the software based on the finite volume method and written in the programming language C++. By simulating the influence of wind on a steel hall in the area of Zenica, the resulting loads were compared with those from Eurocode.

1. Introduction

In a world of commercial software with easy-access user interfaces and full developer teams dedicated to ensuring that the software remains at the forefront of the industry, finding motivation to use open-source software can be tricky. As this will become evident from the rest of the paper, understanding the benefits of using this software is crucial for both academic and industrial environments.

Henry Weller initially created it in 1989 at Imperial College London while working on the development of a CFD code called FOAM (Field Operation And Manipulation). In 1994, Weller released the source code of FOAM, marking the birth of the open-source CFD code. FOAM quickly gained popularity in the CFD community due to its adaptability, expandability, and the ability to modify and enhance the code to meet specific research requirements. Today, it is mainly developed by OpenFOAM Foundation and is under GPL (GNU General Public Licence).

While the software dominates academic spaces, it has long way to go to reach such levels in the industry, where time is much more valuable. In this paper, the software is used to analyse wind loads on a steel hall located in Zenica and its model shown in figure 1. Results are interpreted having current state of the object in mind, available hardware and the design codes it was subjected to.

1.1. Modelling approach

The analysis begins with a choice of solver within the software. This is perhaps the most crucial step since it dictates reliability of the final result. However, this does not mean that choosing a correct solver will guarantee good results, but it will ensure a correct path in which step by step user can converge towards an acceptable solution. Difficulty comes from nature of fluids and their interactions. This means that the smallest change or error can cause significant changes in the final result. Such high non-linearity has forced engineers and scientist into clever solutions. The solver chosen for this particular analysis is

simpleFOAM, which is designed for incompressible, laminar or turbulent flows based on the Reynolds-averaged Navier-Stokes (RANS) equations. The solver utilizes the SIMPLE (Semi-Implicit Method for Pressure-Linked Equations) algorithm, an iterative method employed to couple the pressure and velocity fields. By utilizing the SIMPLE algorithm, the software ensures that the solution adheres to the continuity equation, a fundamental equation in fluid dynamics.

The object analysed is located in Zenica, and is a part of the industrial zone. Zenica is around 330 meters above sea level, which is relevant for wind speed approximations. The base wind speed is taken form Eurokodovi.ba interactive website which allows user to pinpoint exact location of an object and determine relevant wind speed. For the object in question, base wind speed is approximated to be around *20 m/s*. This base speed is used for both simulation and Eurocode comparisons. The object is 15x64 meters with 6 meters height on the sides up to maximum of 7 meters.

Due to computational limitations of the author's hardware, simulation is 2-dimensional and number of cells is limited to the number which resulted in reasonable simulation duration. The domain is divided into 6 hexes as in figure 1, to ensure some level of control over the further subdivision into finite volumes. While the numbering of the hexes is irrelevant, the vertices that define each hex have to be put in specific order to ensure proper orientation of normal vectors for each face. If vertices are misplaced, there will be an error message when trying to generate the mesh.

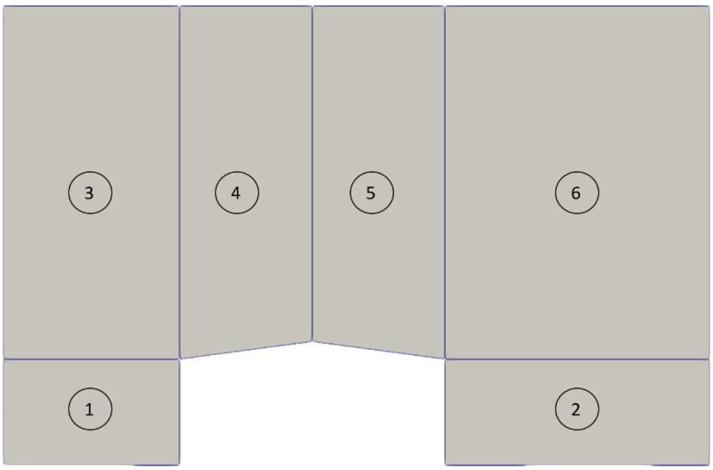

Figure 1. The numerical domain which is to be further divided into smaller volumes.

As it is clear from figure 1, domain upon which partial differential equations will be solved is divided into 6 hexes each containing number of cells given in table 1, having total of 925 000 cells.

Table 1. Number of cells per hex and relevant information about mesh orientation and further grading.

Hex Number	Number of cells	Guaranteed orthogonality	Grading
1	100000	Yes	Simple (0.5 1 1)
2	125000	Yes	Simple (2 1 1)
3	200000	Yes	Simple (0.5 1 1)
4	125000	No	Simple (1 1 1)
5	125000	No	Simple (1 1 1)
6	250000	Yes	Simple (2 1 1)

2. Physical and numerical modeling

As previously mentioned, simpleFoam solver is used to simulate wind interactions. The solver uses SIMPLE algorithm [1], for coupling pressure-velocities.

2.1. Governing equation

The equations governing fluid motion are:

- The incompressible continuity equation:

$$\nabla \cdot \boldsymbol{u} = \mathbf{0} \tag{1}$$

- The momentum equation:

$$\nabla \cdot (\boldsymbol{u} \otimes \boldsymbol{u}) + \nabla \cdot \boldsymbol{R} = -\nabla p + \boldsymbol{S_u} \tag{2}$$

where $\boldsymbol{R}$ and $\boldsymbol{S_u}$ are stress tensor and momentum source respectively. Each of the terms in equations (1) and (2) must be discretization before it is possible to numerically solve them. The turbulence model of choice is k-epsilon [1] and is described by the model equations:

- The turbulent kinetic energy equation:

$$\frac{D}{D_t}(\rho k) = \nabla \cdot (\rho D_k \nabla k) + P - \rho\epsilon \tag{3}$$

- The turbulent energy dissipation rate:

$$\frac{D}{D_t}(\rho\epsilon) = \nabla \cdot (\rho D_\epsilon \nabla \epsilon) + \frac{C_1 \epsilon}{k}\left(P + \frac{2C_3}{3} k \nabla \cdot u\right) - C_2 \rho \frac{\epsilon^2}{k} \tag{4}$$

- The turbulent viscosity equation:

$$\nu_t = \frac{C_\mu k^2}{\epsilon} \tag{5}$$

Equations (3), (4) and (5) have specific implementations in the software.

2.2. Finite volume method

The finite volume method is a numerical method in which domain is divided into finite elements (Volume elements) upon which partial differential equations can be solved. One of the benefits of the technique is that conservation of certain quantities arises naturally as fluxes of conserved quantity across the faces of control volumes are balanced.

The first step in this process is to set up a domain upon which the equations will be solved. This is an extremely crucial step where simulation time cost and quality of results should be balanced as much as possible. A lot of numerical methods are being used to ensure that it is possible to do high quality numerical simulation on lower resolutions. Higher resolutions generally guarantee better results, up to a point in which simulation converges to a solution, after which having higher resolution will not improve the result. Each variable is calculated at the center of each cell which, for 3D flat space, is simply defined as [1]:

$$\int_{v_p}(x - x_p) = 0 \tag{6}$$

The mesh must cover the entire domain and must be made of non-overlaping cells. Each cell is defined by a set of verticies and bounded by cell faces. In order to solve the equatiuons governing any kind of physical behaviour over the mesh, certain information is necessary:

- mutual ratios of control volumes;
- ratios of sides and volumes;
- geometric information about cross-sections, volume centers, side shapes, surface centers, surface area, and normal directions.

Two different kinds of cell faces have to be differentiated:

- internal faces;
- boundary faces.

Internal faces are the ones that border other hexes and need no boundary condition. Those are the faces in figure 1 that border hex number 1 and 3, 3 and 4 and so on, while boundary faces have to be given specific boundary condition before a simulation start. Each term in every equation is discretized and implemented as C++ code.

2.3. Turbulence modeling implementation and boundary conditions

As previously mentioned, each equation has a specific OpenFOAM implementation. The equation (3) and (4) are implemented and documented in the software source code as following:

$$\frac{\partial}{\partial_t}(\alpha\rho k) + \nabla\cdot(\alpha\rho\boldsymbol{uk}) - \nabla^2(\alpha\rho D_k k) = C_1\alpha\rho G\frac{\epsilon}{k} - \left[\left(\frac{2}{3}C_1 - C_{3.RDT}\right)\alpha\rho\nabla\cdot\boldsymbol{u}\epsilon\right] - \left(\frac{C_2\alpha\rho\epsilon^2}{k}\right) + S_\epsilon + S_{fo} \quad (7)$$

Where:

- α – phase fraction;
- ρ – fluid density;
- G – turbulent kinetic energy production rate;
- D_e– Effective diffusivity for ϵ;
- C_1- model coefficient;
- C_2- model coefficient;
- $C_{3,RDT}$ – RDT compression coefficient;
- S_ϵ – internal source term for ϵ;
- S_{fo}- source term introduced in case directory.

$$\frac{\partial}{\partial_t}(\alpha\rho k) + \nabla\cdot(\alpha\rho\boldsymbol{uk}) - \nabla^2(\alpha\rho D_k k) = \alpha\rho G - \left(\frac{2}{3}\alpha\rho\nabla\cdot\boldsymbol{u}k\right) - \left(\alpha\rho\frac{k}{\epsilon}k\right) + S_k + S_{fo} \quad (8)$$

Where:

- S_k – internal source term for k;
- S_{fo}- source term introduced in case directory.

Default coefficients are given in defined in table 2.

Table 2. Default model coefficient values [2].

Model coefficient	Default value
C_μ	0.09
C_1	1.44
C_2	1.92
$C_{3,RTD}$	0.0
σ_k	1.0
σ_ϵ	1.3

The wind base speed of 20 meter per second is taken as an inlet velocity and is incoming form the left side in the figure 1. Relevant boundary conditions for the simulation are defined in table 3, which corresponds to values defined at initial condition directory in the software case.

Table 3. Some of the boundary conditions for the stell hall simulation.

Boundary	u	p	k	epsilon
Inlet	fixedValue	zeroGradient	fixedValue	fixedValue
Outlet	pressureInletOutletVelocity	totalPressure	inletOutlet	inletOutlet
Wall	noSlip	zeroGradient	rqWallFunction	epsilonWallFunction

Each boundary condition is explained in detail in OpenFOAM user and programming guides and trough examples provided with the software installation.

3. OpenFOAM setup

One of the downsides of using the software is that requires Linux based operating systems. This means that user, in order to use the software to its maximum potential, at least some knowledge of Linux based systems is required. While the user interface is text based and can be navigated easily, full potential of the software only comes after user becomes fully introduced into its C++ codebase. For this paper, the software has been installed trough WSL2(Windows subsystem for Linux), which is an easy way to access Linux based systems without much difficulty. The case folder is the place where all commands relevant for the simulation are executed. The folder contains 3 subfolders where contains elements from figure 2.

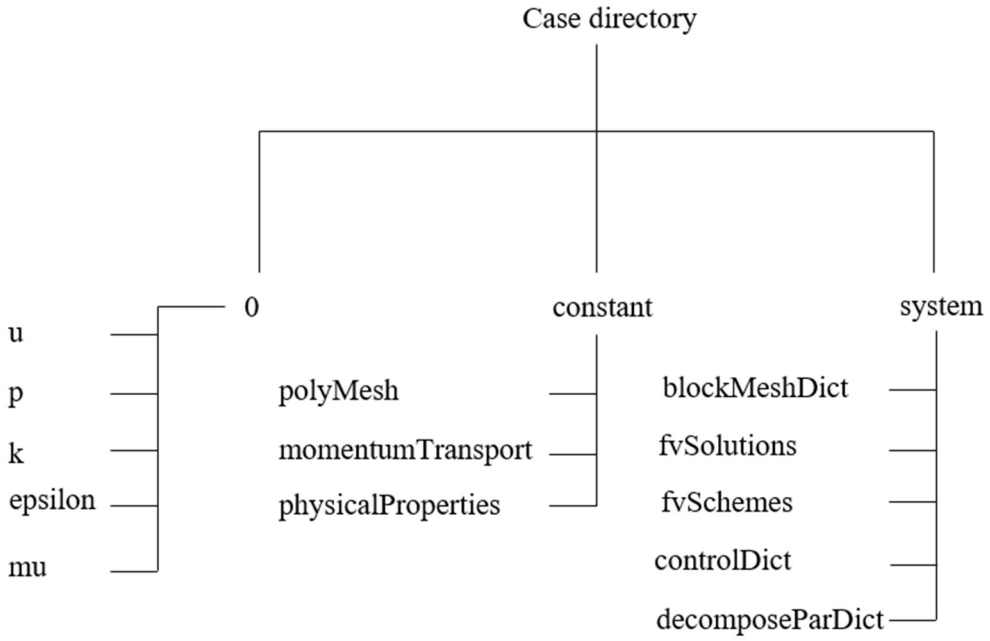

Figure 2. OpenFOAM case structure for the stell hall wind analysis.

The figure 2 represents the case structure for this particular simulation, but it accurately presents general look for every OpenFOAM case. 0 folder is where all the boundary conditions, as shown in table 3, are defined. blockMeshDict is where the mesh shown in figure 1 is defined and the polyMesh folder from figure 2 is generated by running command blockMesh from the case folder. This is how the mesh is generated for the simulation. The generated mesh is then automatically divided into 6 regions and simulation is started by running the command: **mpirun -np 6 simpleFoam -parallel.** While the separation can be done automatically, some of the parameters have to be defined in decomposeParDict file, located in system folder. Here user can define how exactly to decompose a mesh before the simulation**.** The command ensures that simulation is ran at multiple processors at the same time which can drastically reduce simulation time. Since a lot of simulations take time, the software allows for user make sure that some variables are changed during the simulation. In this particular case, in controlDict file, option runtimeModifiable is allowed and time step is regulated such that certain constrains are satisfied without having to stop the simulation.

All of the postprocessing is available through paraView software, which is automatically installed with OpenFOAM. After the simulation, it is required to recompose results from each processor or thread so that the results can be analysed. The recomposed results are separated into folders with the simulating time name so that user can stop and resume simulation from any point.

It is also possible to change some of the initial condition is these folders to make sure the simulation gives the best possible results. The software offers much more utilities which are not shown as part of this paper.

4. Postprocessing

The simulation lasted about 3 hours and achieved convergence. The pressure is integrated over each cell on the wall of the object using ParaView utilities and is averaged according to the figure 3. The results are compared to those form Eurocode1-4 in table 4.

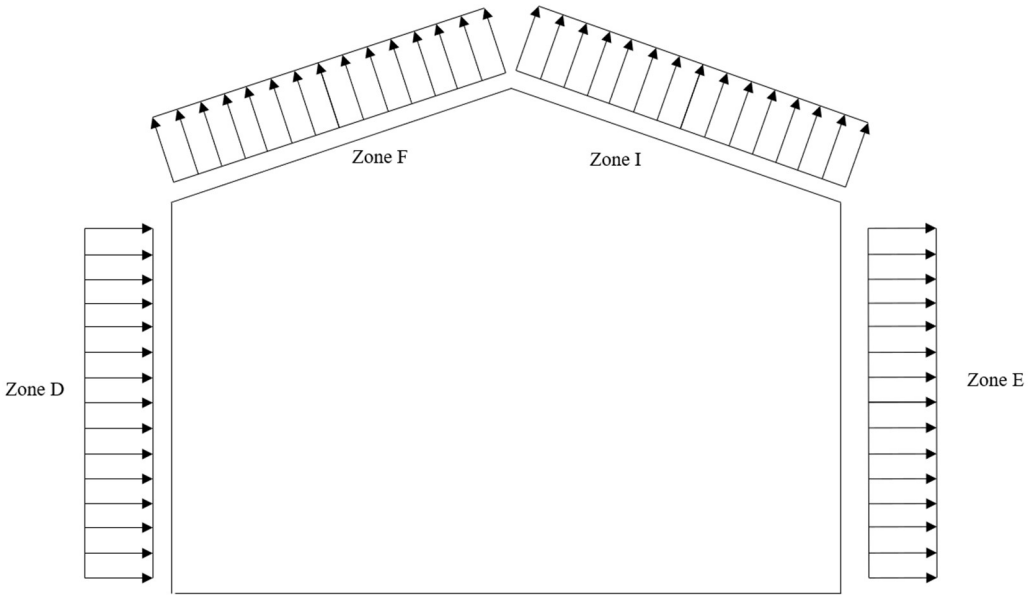

Figure 3. The integrated and averaged results over each cell of the wall and divided into 4 zones.

Table 4. Pressure in kN/m^2 integrated and averaged over the walls form figure 3.

Source	Zone D	Zone E	Zone F	Zone I
Simulation	0.414	-0.701	-1.046	-1.11
EC 1-4	0.441	-0.313	-0.765	-0.367

5. Conclusion

Looking at the table 4, it is obvious that certain results vary from those calculated according to Eurocode. Due to lack of experimental measurements on the object, it is assumed that those from Eurocode are more reliable than the simulation results. This is because k-epsilon model can sometimes give unreliable results if the mesh isn't refined enough, as it is true for any kind of numerical simulation. The offset can also be explained by relative coarseness of the mesh which required greater resolution which, with the available hardware to the authors, was not possible to make.

After further inspection of the object documentation, it can be concluded that even the simulated values are covered by the structural elements of the object.

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Measurement of vibrations on a rotary excavator

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Abstract. In this work, we measured eight reducers distributed in three locations, which have the purpose of starting different ones mechanical parts of excavators. The measurement was carried out by placing accelerometers and velocimeters on two gauges places per reducer, in three mutually perpendicular axes. The measurement was performed "idle", i.e. without point of contact with the ground.

1. Introduction

The rotary excavator SH630 has a working wheel with buckets which in the normal working process rotates at 7 min-1 and thus achieves a projected capacity of about 1000 t/h. The working wheel is powered by 5 hydro motors with reducers located on the working wheel itself. The material is captured via 14 buckets that are emptied on the upper side of the working wheel through openings in the construction, where the excavation is directed to the primary conveyor by means of a receiving bunker. The working wheel and the primary conveyor rely on the supporting structure of the rotary excavator via the main cater. pylon. The pylon is a welded steel structure that takes all the loads and transfers them to the base via a large circular support. The construction of the pylon has the possibility of circular movement. The main Taarka is a welded steel box structure that is suspended from the pylon via two axles and gets vertical movement via a hydraulic cylinder supported in the lower part of the pylon. On the supporting structure itself, there is also a tipping node, through which the excavated material is directed to the secondary conveyor and taken further to the main transport system of the surface mine excavation. The secondary conveyor is driven by two hydro motors with reduction gears and is supported by an auxiliary Taarka. The construction of the pylon is the main supporting structure through which all working loads are transferred to the base. The pylon is supported on tracks that allow the rotary excavator to move on the excavation base (the so-called planum). The appearance of the rotary excavator before overhaul is shown in Figure 1.

Figure 1. Rotary excavator SH 630 before overhaul.

The rehabilitation of the rotary excavator is related to all vital parts of this complex plant. Parts of the steel structure, transport systems, and working wheels with buckets were repaired, and the hydraulic system was also revitalized. The rotary excavator is powered by electricity, which drives the pumps and the entire hydraulic system. All drive motors are hydro motors with reducers and have also been fully repaired.

2. Measurement of vibrations on a rotary excavator

The measurement was performed on eight reducers distributed in three locations, which have the purpose of driving different mechanical parts of the excavator. The measurement was carried out by placing accelerometers and velocimeters at two measuring points per reducer, in three mutually perpendicular axes. The measurement was carried out "idle", i.e. without contact of the working point with the ground[1].

The measurement was carried out in order to obtain a reference state of vibrations that will be used for future control of the state of vibrations. Vibration control was agreed with the customer for approx. 6 months from the first measurement.

Figure 2. Rotary excavator SH 630 on the plateau where the overhaul was carried out.

2.1. Test program

The test program includes the measurement of vibrations on the reducers that drive different parts of the excavator. The measurement was performed on five reducers that drive the working wheel (RT), one reducer that drives the loading belt (UT), and two reducers that drive the unloading belt (IT). The positions of the mentioned groups of reducers are shown in Figure 3.

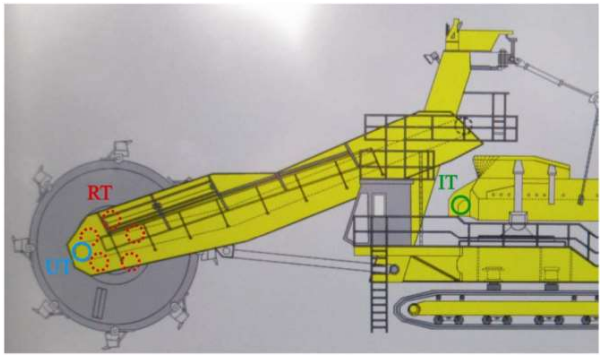

Figure 3. Positions of measuring points: RT - working wheel, UT - loading belt, IT - unloading belt.

The working wheel is driven by means of 5 reducers arranged in a circle. Their layout and markings are shown in Figure 4.

Figure 4. Layout of the impeller reducer.

The unloading belt is driven by two reducers located on each side of the drive drum. If you look in the direction of tape rotation, the right reducer will be marked 1, and the left one will be marked 2. Figure 5 shows the location of reducer IT1.

Figure 5. Position of reducer IT1.

2.2. Selection of measurement sites

Measurements on each reducer were performed using four accelerometers that measured vibrations in the vertical and horizontal directions, and two velocimeters that measured vibrations in the axial direction. On each reducer, vibrations were measured at two ends of the reducer, which are marked as A and B. The positions of the sensors are shown in Figures 6-8

The marks on the pictures represent the following:

- the first letter indicates the direction of vibration measurement (V – vertical, H – horizontal, A – axial)
- the second letter indicates the end of the reducer on which the measurement was performed (A – output end of the reducer, B – input end of the reducer).

The pictures show the positions of the sensors on the drawing of the reducer, as well as their actual positioning during measurement. The positions of the sensors that measure axial vibrations may vary depending on the accessibility of the reducer housing[3].

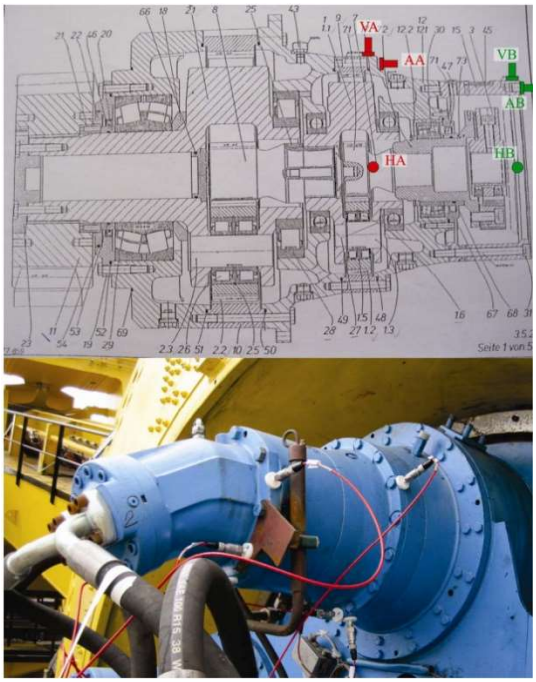

Figure 6. Sensor positions on RT reducers.

Figure 7. Sensor positions on UT reducers.

Figure 8. Positions of sensors on reducers IT.

2.3. Measuring equipment and measuring chain

When measuring vibrations, a universal eight-channel amplifier Spider 8 manufactured by HBM Darmstadt (FR Germany) was used. Piezoelectric accelerometers A-101 produced by CTC and velocimeters VE101-2A produced by CTC were used as sensors for measuring acceleration. In Figure 9. the measuring chain is shown schematically, while Figure 10. shows the layout of the equipment for amplifying and registering the measurement signal[3].

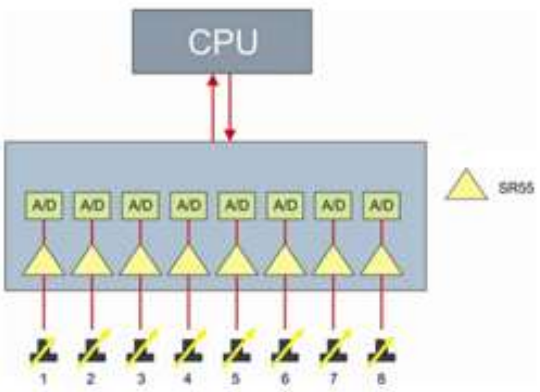

Figure 9. Measuring chain.

Figure 10. Appearance of used vibration measurement equipment.

Using the measuring chain shown in the picture, accelerograms, and velocity diagrams were registered at the measuring points. Measurements were made when the machine was running "empty", i.e. with the working point in operation without contact with the ground. The registered measurements are shown in Appendix A. The accelerograms were transformed into velocity diagrams by filtering and integration. By processing the speed diagram, the values of the root mean square value (RMS) of the signal were obtained, which are shown in Table 1. for all measurements performed[5].

Table 1. RMS values for the performed measurements [mm/s].

Marking of reducer	Measuring point A			Measuring point B		
	V	H	A	V	H	A
RT1	2,8	1,7	0,9	0,9	1,6	2,2
RT2	1,1	1,2	1,0	0,7	1,6	1,2
RT3	1,4	1,3	0,9	0,6	1,2	1,2
RT4	1,1	0,9	1,4	0,8	1,5	1,1
RT5	1,4	1,6	1,2	0,9	1,9	1,4
UT1	1,5	3,1	1,8	0,7	11,4	4,6
IT1	2,7	1,6	1,8	1,2	0,01*	1,7
IT2	1,4	1,1	1,0	0,7	0,01*	3,2

** The low level of RMS was caused by the insufficient tight fit of the magnet on the housing due to the small radius of the housing. The state of the reducer is determined using the remaining 5 measuring points on that reducer.*

2.4. Analysis of results

The root mean square values (RMS) of the speeds recorded on the reducers of the rotary excavator for each reducer are shown in Table 1. According to the ISO 10816 standard, the condition of the machine was assessed based on the comparison of the obtained RMS values with the values shown in Table 2, in which all machines are grouped into 4 groups depending on their size/power and the way the machine is attached to the base. Although the data about the machine is not known, we can assume that the analyzed excavator belongs to group 1 of large machines with a power greater than 30kW and less than 50MW with a flexible connection to the base.

Based on the comparison of RMS values from Table 1. with the RMS speed reference values from the ISO 10816 standard shown in Table 2, it can be concluded that all the working wheel reducers

(RT) as well as the unloading belt reducers (IT) belong to the "new equipment" class. A more detailed diagnosis of the reducer will not be performed[2].

The loading belt (UT) has an increased value of RMS in the horizontal and axial directions at the end of the B reducer. The RMS of the horizontal direction is 11.41mm/s and is on the very border between class C (permitted machine operation) and class D (machine operation is not permitted due to the possibility of damage to the machine due to vibrations). The RMS of the axial direction is 4.85 mm/s, which belongs to class B (unlimited operation of the machine) and can be accepted as such. In the following, a more detailed analysis of the vibrations of this reducer will be performed

Table 2. Machine classes according to ISO 10816.

										Velocity 10-1000 Hz r > 600 rpm 2-1000 Hz r > 120 rpm
			D					11	0,43	
			C					7,1	0,28	
								4,5	0,18	
			B					3,5	0,14	
								2,8	0,11	
								2,3	0,09	
								1,4	0,06	
			A					0,71	0,03	
								mm/s	incs/s	
Rigid	Flexibile	Rigid	Flexibile	Rigid	Flexibile	Rigid	Flexibile			Foundation
Pumps > 15 kW radial, axlal, mixed flow				Medium sized mas 15 kW <P<300kW		Large mashines 300 kW<P<50MW				Machine Type
Integrated driver		External driver		Motors 160mm<H<315mm		Motors 315mm < H				
Group 4		Group 3		Group 2		Group 1				Group

A New machine condition
B Unlimited long-term operation allowable
C Short-term operation allowable
D Vibration causes damage

2.5. Vibration analysis of UT reducers

Due to the occurrence of increased RMS of speed at the measuring point UT-HB, as well as increased RMS of speed at UT-AB, a more detailed analysis of vibrations will be undertaken in order to determine the possible cause of the increased RMS of speed at this measuring point[4].

From the acceleration diagram, frequency spectrum diagrams were extracted, which are shown in Figure 11. It is noticeable that the frequency 66.69Hz dominates all diagrams. On the diagram representing the vertical direction of measurement on the reducer UT at measuring point A, another significant frequency 449.55Hz appears, which also occurs in the vertical direction at measuring point B.

In the vertical direction at position B, the second and third harmonics of frequency 66.69Hz occur, as well as the dominant frequency 236.46Hz.

The frequency 13.48Hz, which is the subharmonic of the most dominant frequency 66.69Hz, was also recorded in the horizontal direction at the measuring point A.

Due to the lack of sufficient data on reducers (number of revolutions, number of teeth on the gears, type of gears), it is impossible to determine with certainty the causes of occurrence of certain frequencies. The most dominant frequency 66.69Hz is probably the frequency of rotation of one of the gears in the reducer multiplied by its number of teeth. An increased amplitude of the gearing frequency with slightly increased amplitudes of the rotation frequency of the shaft carried by the gear

(in our case the frequency 13.4Hz or one of its subharmonics) most often indicates an excessive load on the teeth (or teeth) caused by misalignment. On the other hand, a high gearing frequency amplitude value does not always indicate a problem with the gears[6].

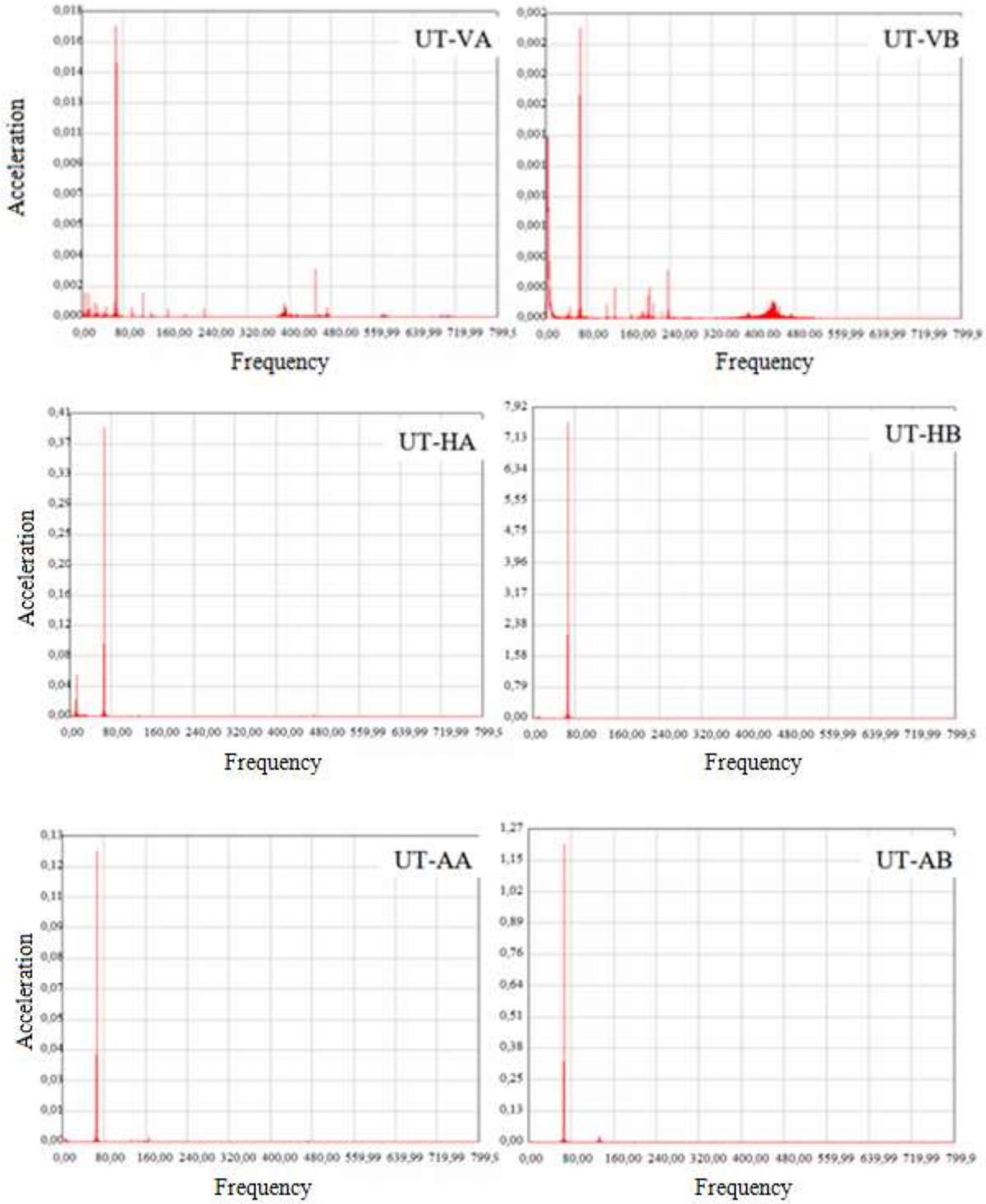

Figure 11. Frequency spectra for reducer UT.

3. Conclusion

Measurement of vibrations on the SH 630 rotary excavator at the Šikulje surface mine was performed on hydraulic motor reducers during the transition stroke of the excavator. The measurement was performed on five reducers of the working wheel, one reducer of the loading belt, and two reducers of the unloading belt.

Analysis of the results showed that with all reducers of the working wheel and both reducers of the unloading belt, the RMS speed is within the limits that meet class A according to ISO 10816, i.e. the "new machine" class. Class A does not require additional analyses, and they were not conducted for the above measurements.

On the reducer of the loading belt, an increased value of RMS in the horizontal and axial direction was determined by analysis. The measured RMS value was 11.41 mm/s for the horizontal and 4.85 mm/s for the axial direction. The RMS speed in the horizontal direction represents the limit value between class C and class D according to ISO 10816 and can be classified into class C. According to standard 10816, machines that meet class C are allowed to operate the machine for a short time, with planned future maintenance. Given that a re-check of the state of vibrations on the reducers is planned in six months, the true state of the machine will be known only after the planned check. However, the analysis of the frequency spectrum revealed a dominant frequency amplitude that probably represents the frequency of rotation of the gear multiplied by the number of gear teeth. The appearance of this frequency usually does not mean that there is a problem with the gear. If there is a problem with the gear, the specified dominant frequency indicates a misalignment of the axis of rotation of the gear.

Due to the lack of data on the properties of the reducer (power, number of revolutions, number of teeth on the gears), diagnosing the condition of the reducer of a rotary excavator and defining the cause of certain phenomena is practically impossible. However, the measurement was performed for the purpose of collecting reference data that will serve as initial data in monitoring the condition of the reducer on the rotary excavator. It is suggested to re-measure the vibrations on the excavator in approx. 6 months.

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The tradition of the old house and the new technology of building houses in Bosnia and Herzegovina

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Abstract. In this paper, an analysis of three types of old construction and one example of low-energy house construction was performed, the advantages and disadvantages of each compared to the other were presented. Old houses are buildings that have changed throughout history according to the style of construction and the materials from which they were built. The analyzed types of houses are ground floor and first floor. Low-energy houses are built from new materials that are exclusively made of natural materials without synthetic additives, one of such products is "thermo block". Walls made of thermo blocks provide good vapor permeability properties and good sound insulation, and in combination with additional thermal insulation also have good insulating properties.

1. Introduction

In the beginning, people found shelter where they could, they took shelter in hiding places, so they considered such places as their homes. Later, they began to arrange their habitats in various ways.

Depending on the climatic zones, people made habitats, so in warm areas, they could live on trees, they tied or interwoven branches into a kind of frame over which they put sod grass. Living in such habitats, our ancestors were protected from the sun, rain, flood, and wild animals that could not climb the tree. However, in areas with a cold climate, a wooden house did not represent protection, so man used caves, in front of which he lit a fire at the entrance. Later, people tried to dig holes in the hillsides to build caves. They also found natural depressions in dry and drained places and built them up with a stone wall. In various parts of the world, houses adapted to the climate and activities of the inhabitants began to be built.

At the beginning of XX. century, the types of old houses that will be discussed in this paper were used in these areas. These are buildings that have changed throughout history according to the style of construction and the materials from which they were built. The subject houses have the same story, ground floor, and one floor with a hipped roof. The ground floor served different purposes depending on whether the house was located in the city or in the country, in a country house it usually served as a barn with farm animals. In urban areas, craft shops or shops were usually located on the ground floor of the house. On the upper floor, which in some cases was wider than the ground floor due to the need for more space, there were living rooms. They were of different sizes, the largest room was used for the living room, and the smaller ones for the sleeping of the household.

2. Types of old houses

Throughout its long history, old houses were built from various materials, and in this paper, we will consider three types:

- a wooden house
- stone house
- stone and wood house

2.1. House made of wood

Wood is one of the oldest materials for building houses as a structure. The use of wood for construction dates back to the time when man began to build the first buildings, i.e. when he began to build shelter for himself [1].

Wooden constructions, by definition, are a set of wooden elements, through which specific and purposeful spaces are formed and through which certain loads are transferred. Wood is permeable in both directions, unlike PVC and reinforced concrete. This is why building a wooden house creates a healthy, oxygen-filled, and naturally moist space that is ideal for living. Wooden houses are simpler, cheaper, and more suitable for construction. This fact is also evidenced by the massive construction of wooden houses in the residential architecture of the developed West. The most common types of wood are fir, spruce, oak, ash, teak, and rosewood [5].

The construction of an old wooden house in Bosnia and Herzegovina is shown in Figure 1, and it was built in the town of Donja Koprivna, municipality of Cazin. The house has a ground floor and a first floor. The characteristic of this house is that the first floor was expanded in relation to the lower part because there was a "living" space on the floor and there was a need for a larger space.

Figure 1. Old wooden house.

When building the house in Figure 1, the building material is wood, along with other natural materials: stone, straw, clay, etc. The lower part of the house is made of solid wood. The upper part is a skeletal structure made of wood, filled with wicker, straw, and clay. The roof structure is steeper and shingles were used as covering material. The foundations of the building are made of stone, the upper part of which is attached to the construction of the house with wooden forms, and the lower part is buried in the ground, which is shown in Figure 2a). The construction of the ground floor is made of wooden columns, beams measuring 0.30m x 0.30m, and planks which are connected to each other by connecting elements such as cornices, nails, thorns, clamps [4]. The stairs or basamacs were made of wood, one-legged, leading to the first floor of the house on the veranda.

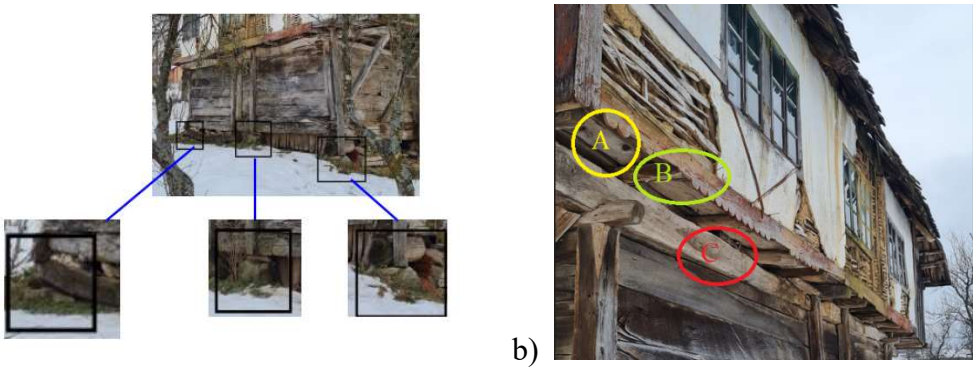

Figure 2. a) Stone foundations tied with wooden forms for construction b) Intermediate floor constructions: A - board with a thickness of 0.03m to 0.05m; B - beam with a diameter of approx. 0.15x0.15m; C - beam with a diameter of approx. 0.30x0.30m.

The mezzanine construction near the building in Figure 2b). are wooden beams with a diameter of approximately 0.30m x 0.30m and an interaxial distance of about 3.0m - 3.5m, over which new wooden beams with a diameter of about 0.15m x 0.15m and an interaxial distance of about 1m are placed. Over the beams, a 0.03 to 0.05 m thick board joist was made. The ceiling of the house was connected to the ceiling joists with wooden rivets, over which reeds were riveted, which were plastered like the facade part.

The walls of the upper dial, ie. of the residential part of the house were built from wooden columns as a structural or load-bearing part with dimensions of 0.3x0.3m, and the wall infill consisted of wooden rods that were plastered on the outside and inside, which can also be seen in Figure 2b). Clay was most often used as a heat insulator and straw as a binding material or reinforcement for plasters in these houses. The windows were rectangular in shape and made of wood and glass, which are located in a row arranged at regular intervals due to the light entering the building, which is one of the characteristics of the Bosnian house building style. The roof of this house is made of a wooden structure of beams and laths, and the covering is made of hewn wood, the so-called "Shimla", Figure 2. The roof structure is connected to the load-bearing structure of the building via beams, and they are connected with steel flanges and cornices. The advantage of these houses was that wood is permeable in both directions, unlike PVC and reinforced concrete. Therefore, building a wooden house creates a healthy, naturally moist space that is ideal for living [1]. Wood is a good building material, resistant to bending perpendicular to the fibers, as well as to pressure in the direction of the fibers. It is also a good ecological material, a permanent CO2 container, and the costs of processing, transportation, and construction are lower than with concrete, masonry, or steel. Wood is built quickly, and the buildings are immediately dry and fit for living. Wood also has better fire resistance than steel and reinforced concrete, because its slow-burning allows for a longer load-bearing capacity of structural parts in a fire. The wooden structure, as an elastic system, behaves well in the event of an earthquake. This applies equally to the system of traditional construction of houses with horizontal planks with wooden beams. If we talk about anti-earthquake properties, wooden construction has two advantages compared to classical construction: on the one hand, it has a small mass, so it is less sensitive to shearing and twisting, and on the other hand, its joints, classic carpentry joints or engineering metal joints, they compensate for movements and impacts, that is, they disperse impact energy, turning it into thermal energy, thus mitigating impacts. Wooden houses are simpler, cheaper, and more suitable for construction. This fact is also evidenced by the massive construction of wooden houses in the residential architecture of the developed West. The disadvantages of wood are that it is: flammable, moldy, rots, bends, and is a favorite delicacy of many insects. That is why good protection, special storage, and drying conditions before use are important.

2.2. Stone houses

Stone as a building material, due to its physical and mechanical properties, was widely used in construction during the construction of old civilizations whose buildings testify to the durability and strength of stone as a building material. Its thermal conductivity also depends on the density of the stone. The construction of the old stone house is shown in Figure 3.

Figure 3. Stone house.

The opposite of thermal conductivity in stone is resistance to the effects of frost, i.e. less dense stone is porous, absorbs significant amounts of water that expands after freezing, and causes additional stresses that can cause the stone to crack. A stone with a higher density and strength has a better resistance to the effects of frost. The stone is resistant to high temperatures up to 550°C, while it disintegrates at temperatures from 600°C to 800°C. The foundations of the house in Picture 3 were built of stone, the lower part of which was buried in the ground. The side walls are made of pressed or hewn stone, built in lime or lime mortar. They are built with two faces with a thickness of 0.60 to 0.80 m. The structure of the stone walls is characterized by the fact that both the outside and the inside are made of selected and carefully assembled stone, while the core is filled with broken and small stones. The upper floor of the house was extended for a veranda, which is reached by wooden stairs according to picture 3. The ceiling above the ground floor - is built of wooden beams, among which the structure of the "shasavac" is often pressed, which takes over part of the stress of the beams under pressure. The floor of the upper room is made of boards that are placed vertically on the beams. The windows in the stone wall are made of small formats, due to the technical possibilities of creating openings in stone walls. Each window had single-wing shutters for protection from the sun, as well as from the wind, and they were once the only elements for closing the window. Over time, the openings become larger, rectangular, single, and double. The windows on the first floor are larger and more numerous due to the greater need for light in the living area. The four-pitched roof of the house is made of wooden beams, rafters, and laths, which are attached to the walls of the building via cross beams, and the roof is made of tiles.

2.3. House made of stone and wood

In a house made of wood and stone, the foundations and walls of the ground floor are built of stone as a building material, picture 4. Instead of a massive stone wall, the upper part of the floor is built of a far more economical solution of a bondruk wall, composed of two different parts, different in size and by material: constructive that receives all vertical and horizontal loads and fillings that only have the function of partitioning. The structural part consists of a series of vertical wooden columns on relatively small elements: aprons, i.e. lintels, and window sills. In some fields, inclined elements (slanted elements) form an assembly that is able to receive and transmit all vertical (from the roof and ceilings) and horizontal loads from the wind [5].

Figure 4. House made of stone and wood.

Partition walls on the first floor are built of a wooden skeleton filled with wooden rods and are plastered with a mixture of clay and straw as a binding agent, i.e. with reinforcement, picture 4. The roof structure is made up of hotels (margins), rafters, cornices, and cornices, Dirac and Kosnik, which are attached to the walls of the building via wedding beams. Tiles were used as a cover, which we can see in Figure 4. The specificity of this house is that it has picked up the good characteristics of previous types, namely: the stability of a stone house, and the comfort of living in a wooden house. The disadvantages are the impact of wood on climatic changes during wetting and drying, which can be prevented by good protection of the wood before installation.

3. New construction technologies

Today, residential houses are made of new building materials compared to previous types of old houses. Full attention is given to the thermal insulation of the buildings themselves, and for this reason, building elements are used that are good thermal insulators, and on the other hand, the buildings are accompanied by concrete elements that give them strength.

The foundations of the buildings are made of reinforced concrete (AB) which is buried in the ground at least 0.9m due to the frost zone in these areas, also the plinth and base plate are made of reinforced concrete. The walls of the house are made of heat-insulated blocks called "thermo blocks", and they have different diameters from 0.15 - 0.4 m, blocks with larger diameters are used for the main load-bearing walls, and blocks with smaller diameters for partition walls. Interfloor constructions are made of AB, which are covered with thermal insulation elements. The roofs are built from wooden beams that are attached to the built object via AB cerclage on the walls, rafters between which mineral wool is placed as a heat insulator, wooden battens over which a vapor-permeable and waterproof film is placed, counter battens and battens that form the air space on the roof after of which the tile is used as a cover.

3.1. Low energy houses

The low-energy house (hereinafter: NE house) is becoming more and more a building standard today, so there is no longer any need to consider it in the world of something "abstract". An almost zero-energy building is a building that has very high energy properties. That almost zero or very low amount of energy is met from renewable sources, including energy from renewable sources that are produced on the building or in its vicinity, and for which the requirements are determined by regulation [10].

Figure 5. Low-energy house.

Heat accumulation is the property of building materials (elements) that they can accept the heat brought to them, accumulate it in themselves, and give it back to the environment when the environment cools down. Heat accumulation is a very important property of building elements, especially in the winter period, and that is the case when the heating in the building does not work continuously for 24 hours but is interrupted occasionally (eg at night).

The good ability to accumulate heat ensures that during periodic heating, the air temperature in the room does not decrease significantly.

The amount of heat accumulated in the building elements is higher, the greater the difference between the temperature of the elements and the temperature of the surrounding air and the greater the specific heat capacity of the building element material and the mass of the element (concrete, reinforced concrete, solid brick, etc.). The property of heat accumulation in the construction elements of the building in the winter period can be characterized by the heat accumulation coefficient W, which is equal to the amount of heat that the external construction element accumulates per unit of its surface, for a unit difference in the temperatures of the indoor and outdoor air, when a stationary state is reached.

High-quality orientation, i.e. orientation of the building with glazed parts towards the south, ensures thermal gains, i.e. the so-called passive heat gains in the building. This also ensures significantly lower energy consumption for heating in the heating season. On the other hand, buildings facing the north must be closed as much as possible and additionally protected from the adverse effects of the wind, which can increase the heat losses of the building to a greater or lesser extent.

The layout of the rooms inside the building also plays a very important role. "Cold" rooms should be placed on the north sides, "warm" ones, which are used more and where less movement is made, on the south sides of buildings. What is unfortunately often forgotten when designing low-energy buildings is proper ventilation of the interior spaces. If we are talking about airtightness (a more accurate name would be water tightness), this does not mean that the building should not have a permanent, or at least constant, inflow of fresh air. Finally, according to the regulation, it is necessary

to ensure a minimum of 0.5 air changes/h, either by natural or forced ventilation exclusively with heat recovery. Natural ventilation means sudden and short-term air changes during the day.

4. Results

The construction of wooden houses has been constantly increasing in recent years, due to the many advantages of wooden buildings compared to those of classic (concrete/stone) construction, namely:

- fast construction and the buildings are immediately suitable for occupancy,
- better fire resistance than steel and reinforced concrete,
- due to its good elasticity, it behaves well in the event of an earthquake,
- joints, classic carpentry joints or engineering metal joints, compensate for movements and impacts, i.e. disperse impact energy, turning it into thermal energy, thus mitigating impacts,
- wooden houses are simpler, cheaper, and more suitable for construction.

The construction of stone houses changed over time with the construction of houses made of concrete, i.e. concrete blocks, and today also blocks of baked earth, i.e. bricks. The specification of the percentage of material used by the types of traditional old houses that were processed and the type of low-energy house was taken as a comparison parameter, and the obtained results are shown in diagram 1.

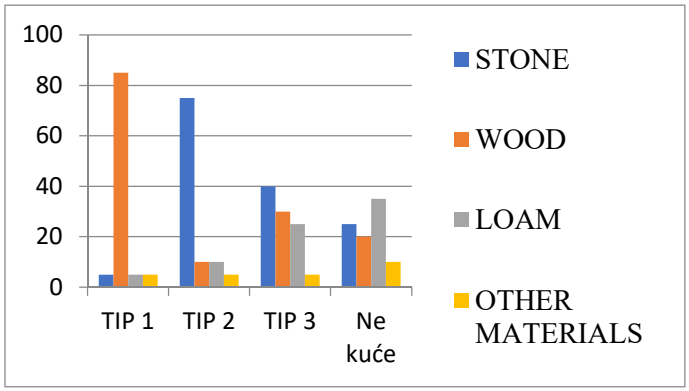

Diagram 1. Specifications of used material by type of traditional old houses.

From diagram 1, it can be seen that in type 1 houses, the most represented building material is wood, approx. 85%, while earth, stone, and other materials account for approx. 5%. In type 2 houses, stone is the most common building material with around 75%, wood and earth around 10%, and other materials around 5%. Type 3 represents the following ratio of used material: stone about 40%, wood about 30%, earth about 25%, and other material about 5%. When building the NE house, we have a representation of stone materials of about 25%, wood of 20%, earthen materials of 35%, and other materials of about 10%. According to diagram 1, it can be concluded that in the NE house, all-natural materials are represented equally, and therefore it is easier to get certain amounts of material.

5. Conclusion

Wooden houses are simpler, cheaper, and more suitable for construction, which is evidenced by the most massive construction of wooden houses in the residential architecture of the developed West. Wood is used in construction today as an indispensable material, almost no house is built without the use of wood as a construction material. Stone as a building material, due to its physical and mechanical properties, was widely used in construction during the construction of old civilizations whose buildings testify to the durability and strength of stone as a building material. Today, the stone is used in smaller quantities and is exclusively used as a decoration, i.e. decorative material. Today's construction facilities are built from mostly new non-natural materials. By examining the characteristics of these three types of buildings, it was established that type 3 of the building contains the positive sides of building types 1 and 2. This achieved the stability of the building, considering that

the walls of the ground floor are made of stone walls up to 0.80 m thick, the upper part of the floor is instead of massive of a stone wall built from a far more economical solution of a wall made of wood on bondruk, composed of two different parts, different both in terms of size and material: the structural part that receives all vertical and horizontal loads and the infill that only has the function of partitioning.

Nowadays, there is an increasing trend towards the construction of low-energy houses, both because of energy saving and the cheapest possible heating of the house as a living space, and because of EU funds that finance the very construction of passive houses, and therefore energy efficiency projects.

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3D Animation of a Minimalistic House

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Abstract. Minimalism, a style which has started as an art movement, has spread all over the world and influenced many disciplines, including architecture. This paper presents a 3D animation of a minimalistic house project, based on several buildings built by well-known minimalist architects. The elements, principles and characteristics of minimalism, related to the form of objects and used material, will be analysed and applied to create a model of a minimalistic house. The project will be presented through floor plans and a 3D model.

1. Introduction

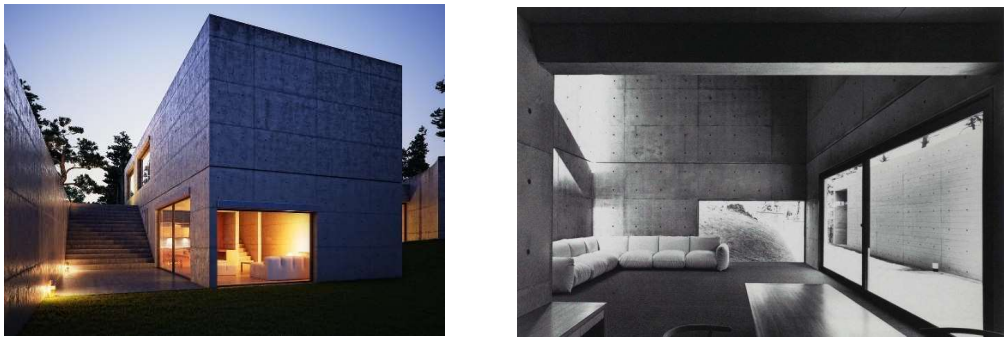
One of the ideas in modern architecture is simplicity. The contribution of the idea of simplicity in architecture is represented by minimalism, which is also called contemporary architecture of simplicity [1]. During the 1950s, the idea of minimalism was presented as a universial language in art and architecture [2]. Architectural examples of minimalism combined with the possibilities offered by new materials and technologies contribute to the triumph of aesthetics, which has become a symbol of time. By analyzing the examples of minimalist architects, common elements and radical differences can be seen [3].

2. Theoretical segment

The first thought of a minimalist lifestyle, and a life without many things in general, we probably associate with the way of life of people within many kinds of religions where it is a virtue to be more connected to the spiritual world rather than the material world. As an example we can give Buddhist or Christian monks who live a simple life, with minimal material possessions and a strong focus on spiritual and religious fulfillment. Minimalism often involves creating space and renouncing excess material things (decluttering) that are not considered necessary for everyday life. A minimalist lifestyle is often associated with an enviromentally friendly lifestyle. Lack of ownership is often associated with less impact on the enviroment. The connection with nature is not always only on a material basis, but also on a psychological or spiritual level, which is often mentioned by minimalists. There is a possibility that minimalism as an idea started in Asian countries, primarily in Japan even before industrialization [4].

Minimalism represents creativity that tends to exclude everything unnecessary in art [5]. Minimalist architecture is based on the use of a few simple materials. Modernism introduced materials such as glass, concrete and steel, which were used to create simpler structures by many architects, including Tadao Ando and John Pawson. Minimalism in architecture focuses on simplifying the form of an object, and focuses attention on materials, surfaces and details. Glass as a building material creates a feeling of openness and gives the illusion of a larger space [6]. Tadao Ando is one of the first architects who introduced minimalism in the eighties of the last century. He developed a unique aesthetic in the creation

of space, created by the interaction of materials (concrete, wood) with nature (water, light). Cubic concrete house – Casa Koshino is shown in figure 1.



a) exterior b) interior

Figure 1. Tadao Ando: Casa Koshino 1980. [7].

According to Tadao Ando, three elements are necessary for architecture. One of them is the material itself. Original, real material such as bare concrete or natural wood. The second element is pure geometry, the base of the structure that keeps the work in present. The third element is nature, not nature in its untouched state, but nature that has been given order by man [8]. He uses a limited number of materials in his works, primarily cast concrete, but also natural wood for floors, doors and furniture [9]. Visible concrete with an elaborate texture design does not require further finishing but remains exposed in that form. Heavy and solid concrete walls give people a sense of stability and security [10].

In the works of John Pawson, it is not the material that is used that matters, but the way in which it is used [6]. Large pieces are used and monolithic materials, like solid marble, are considered to have an intellectual simplicity, figure 2.

Figure 2. John Powson: Monastery of Aur Lady od Novy Dvur, 2004. [9].

According to Pawson, the idea of minimalism is the elimination of the clutter of everyday life [11]. The design of Pawson's two-story family house in Germany consists of one fully open floor, while the second floor is semi-underground. The living room and kitchen are on the lower level, directly connected to the outdoor terrace and the garden behind it [12].

During the construction of a house in this minimalist style, attention should be paid to building materials and their quality. It is often a monolithic construction, where the most common materials are glass and concrete. It is recommended to use blocks made of aerated concrete and foam concrete, thanks

to which the construction process is accelerated, and in addition, the rigidity of the shape and the purity of the lines are maintained. Minimalist houses are often plastered and painted in bright colors. Also, clinker panels and natural wooden panels look very harmonious. The combination of concrete, composite panels and wood will look elegant and unusal [13, 14, 15].

The style of minimalism requires a sense of proportion. After all, its beauty is contained in conciseness, simplicity and naturalness. Various decorative elements, such as facade painting or stucco, are not included. Small details are allowed only if they are made by hand from natural materials. These are often door handles, discrete forged elements or stained glass windows in a neutral color. All this will give the house originality and exclusivity. Minimalism is actually not just a style in architecture, but a lifestyle with reflections in architecture, applied art and fine arts in general, as our interlocutor explained to us. In architecture and art, it is characterized by ignoring decorations, ornaments and combining and mixing colors. Minimalism in itself does not mean sterility and lack of individual touch, it means more order, harmony, peace, purity of forms, balance of volume, surface, color. Minimalist house projects fully embrace the ability of materials to transform when shaped by light that allows them to „shift“ so that they affect our senses. Light is in direct connection with materials, making them visible, while refraction in different ways allows color and surface to be observed. The relationship between material and light has become extremly important, because it is through it that the expressive character of the material is built. Appropriate modulation of light enables its subtle relationship with the material, causing its transformation in the sense of „movement“ [16, 17, 18, 19].

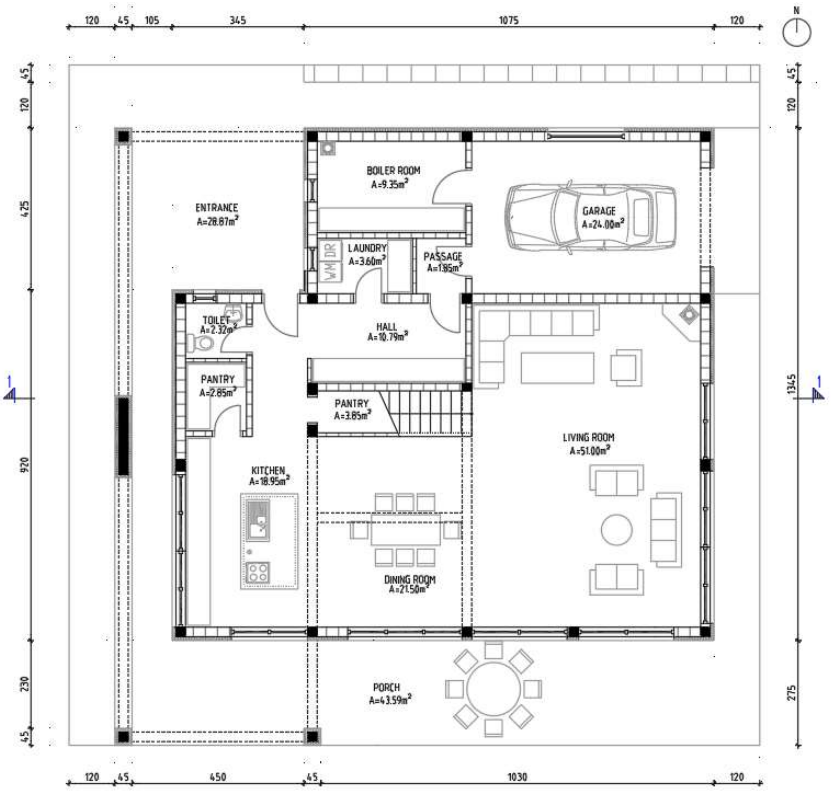
In minimalist architecture, different materials can be used, such as plaster and mortar used for the final coating of walls and ceilings, steel as a structural element, wooden column, figure 3.

Figure 3. Materials in minimalism [20].

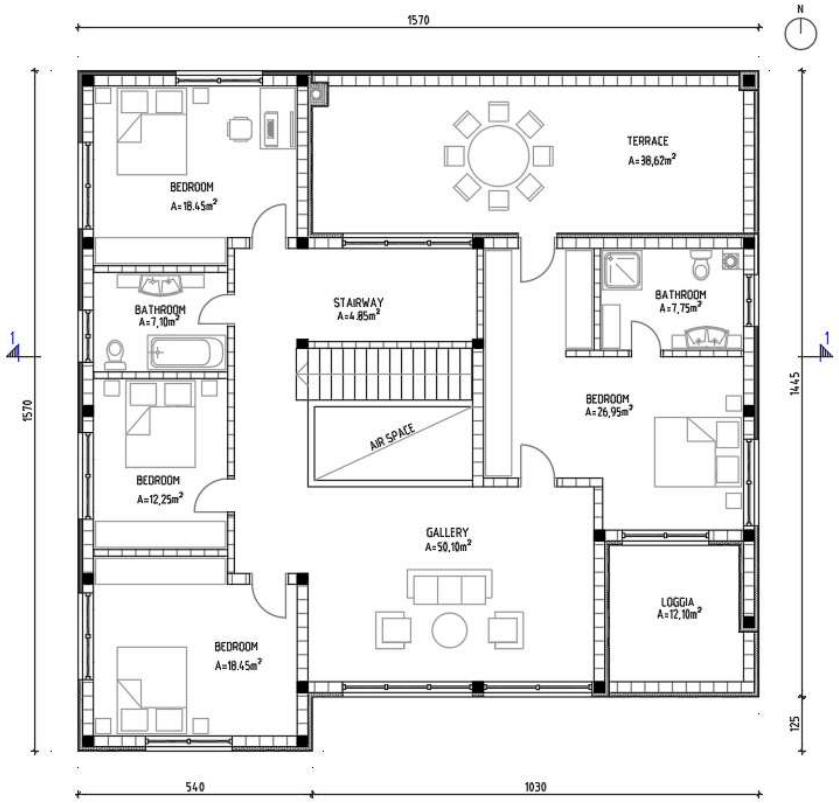
3. The model

3.1. Floor plans

The task of the concept project is to present the author's basic idea in a functional and aesthetic sense [21]. Figure 4 shows the layout of the rooms on the ground floor and first floor. The initial idea was to form a floor plan arrangement of rooms by creating the basic geometric shape of a square.



a) Ground floor



b) First floor

Figure 4. Floor plans.

This modern minimalist house is designed with a concept of simplicity and modern minimalist touch. The architectural design has minimal details using natural materials on the exteriors, like concrete, stone, glass and wood. Common living areas and service rooms (garage, storage, laundry) are located on the first floor. There is a big great room with an open kitchen and dining. This open-concept indoor living is directly connected to a covered outdoor patio and landscape.The bedrooms are located on the second floor and totally private. All upper rooms have great exposure to the surrounding scenery. The master suite is facing the main view at the back with a viewing deck. The master suite has a private bathroom, while the other bedrooms have access to a common bath.The other three bedrooms are for children or guests. The position of these bedrooms are on the other end of the hallway so they would have their own privacy and won't disturb the master suite. The roof of the building is made as a flat roof with a final layer of gravel.

3.2. Three-dimensional representation of the object

With the development of computer programs, the three-dimensional representations of objects provides the possibility of creating a realistic model of the object in the ARCHICAD and Lumion programs, figure 5.

a) Southern facade

b) Eastern facade

c) Northern facade

d) Western facade

Figure 5. Three-dimensional representation of the object.

ARCHICAD and Lumion software were used to create a three-dimensional representation of the object. The dimensions of the building, the position and dimensions of the openings (windows and doors) are copied from the floor plan of the ground floor and first floor. The outer walls of the ground floor are covered with decorative stone, while walls of the first floor are concrete, combined with wood on the southern facade. The building has a large number and surface area of openings. The flat roof also contributes to the modern aesthetics of the building.

4. Conclusion

The contribution of the idea of simplicity in architecture is represented by minimalism. Minimalism in architecture cleans the space from unnecessary elements. The choice of material is as important as the way it is used. Minimalist architecture is usually characterized by basic geometric shapes, a flat roof and modern materials such as concrete, steel and glass. Several common characteristics are noticeable

in the analyzed examples of minimalist architecture: the cubic form of the buildings, the use of concrete as the final lining of the interior and exterior walls, large windows and a neutral color palette.
The model of the minimalist house shown in this paper is a residential building with two floors. The open concept of common areas, good lightning and flat roof give this model a modern and timeless look. Decorative stone on the walls of the ground floor and concrete walls of the first floor in combination with wood were chosen for the facade cladding.

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Reduction of the heat transfer through building windows

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Abstract. From the aspects of energy efficiency in buildings, i.e. heat losses as a relevant factor in the energy efficiency of a building, it is important to emphasize the role of facade openings, windows and doors. Losses on the facade openings have a significant share in the total losses of the building, and they also represent the places of the greatest heat energy inflow in the summer period, depending on the orientation. The heat transfer coefficient on the glazed part of the window ranges between $0{,}8 W/m^2K$ and $3{,}5 W/m^2K$ and depends on the layers of the glazed part; thickness and type of glass, thickness and filling of the space between the glasses (vacuum or inert gas). The paper will analyze the influence of these factors on the reduction of the heat transfer coefficient and look back and analyze the appearance of potential thermal bridges at junction of the facade opening and the structure of the building.

1. Introduction:

Heat can be transferred through the window assembly in three ways; by conduction (heat transfer by touch, i.e. through a solid), by convection (heat transfer by interaction fluid solid wall) and radiation (non-contact heat transfer by electromagnetic waves, only through gas media..). Transmission (diathermy), reflection , absorption, are characteristics that determine the transfer of radiant energy.[1]

In addition to the type of glass and possible additional coatings and films, the number of glass surfaces within the window assembly plays a very large role in the energy characteristics of the window. Although the thermal conductivity of glass is very good, the use of multiple glass surfaces reduces heat loss due to the greater number of layers of insulating air between the glass surfaces. In addition to poorer energy performance, the disadvantage of single-paned windows is the possibility of condensation, which is why many building regulations prohibit the use of such windows. Due to the weight of the window construction, difficult installation, and handling, the window insulation unit can contain a maximum of four glass surfaces. Double-glazed units are most often used, while in quadruple glazing, thin plastic films are often used instead of two glass surfaces, which achieves the energy performance of a window with four glass surfaces and the weight of a window assembly with two glazings. [1]

2. Critical points of heat transfer

The biggest losses of thermal energy occur through facade openings and through window glazing, these losses are as much as 70% of the total thermal energy losses of the building. [5]

Windows are one of the main sources of heat loss in buildings, however, windows can be improved as a thermal insulator to reduce energy losses.

Common single-layer windows have a low resistance to heat transfer. Double or triple-insulating glass consists of several layers of glass with air or inert gas between them. These layers reduce heat loss through the window by creating an insulating layer.

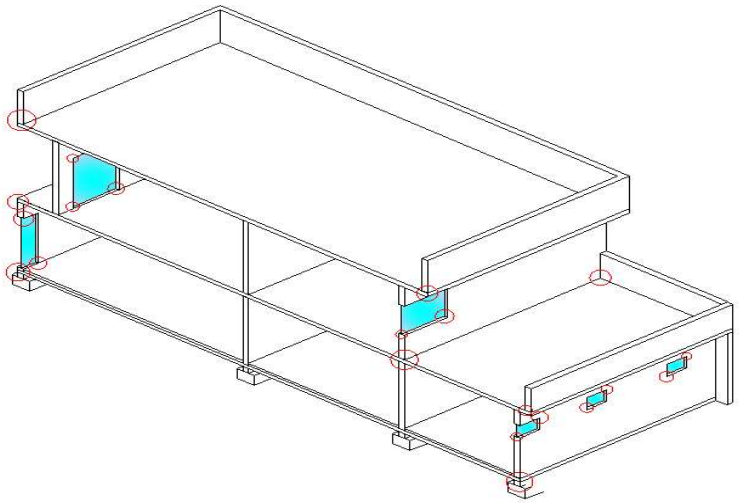

Figure 1. Presentation of critical points of thermal energy passage [5].

Additional heat transfer protection is the Low-E (low emission) coating, a thin layer applied to the glass surface to reduce heat transfer. This coating reduces the passage of infrared radiation through the window, which reduces heat loss during winter and heat entry during summer.

Window frames can also be a source of heat loss. Using materials with low thermal conductivity, such as PVC, wood, or aluminum profile, can reduce heat transfer through the frame. Sealing or avoiding the leakage of air or gas from the expansion between two panes is a key factor for efficient thermal insulation, a sealing tape or other thermal insulator is mainly used to prevent the entry of cold air from outside.

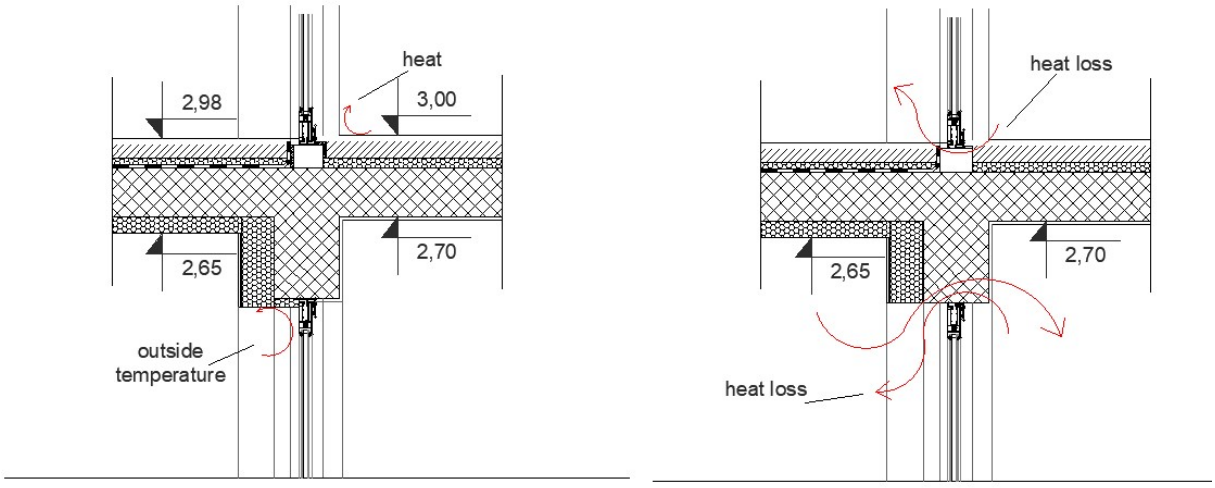

Figure 2. Display of thermal energy losses [5].

A thermal bridge near the window can cause a loss of heat and cold in the room, which leads to higher energy costs and less comfort.

Table 1. Heat losses through external openings [5].

The name of the opening	n	A_w	U_w	H_D
300x160	1,00	4,80	0,66	13,46
300x210	1,00	6,30	0,66	1,85
150x60	1,00	0,90	0,66	0,63
120x210	2,00	2,52	0,66	1,98
320x210	1,00	6,72	0,66	0,71
70x50	1,00	0,34	0,66	1,11
60x60	2,00	0,36	0,66	1,11
110x100	5,00	1,10	0,80	1,68

Table 1 shows heat energy losses through window glass, the analysis showed that the larger the window panes, the greater the heat losses.

3. Problem solving analysis

There are several ways to solve the passage of heat through windows. Double or triple thermal insulating glass, this type of glass reduces the transfer of heat through the windows by creating an insulating layer between the glass panels. By using Low-E coating, heat radiation is effective back into the room, reducing heat loss. Blinds are an additional window insulator because they reduce heat transfer and prevent direct solar radiation. To reduce heat loss, an insulating thin reflective film is used, which is placed on the inside or outside. It reflects heat radiation and can reduce heat transfer.

Table 2. Examples of energy consumption for heating with fuel oil per m^2 of surface with different types of windows [2].

TYPE OF WINDOW	W/ m^2K coefficient	Annual fuel consumption (l/m^2)
Old wooden windows with single glass	4.5	50
Old wooden windows with double IZO glass	2.8	30
PVC windows with 3 chambers and double IZO glass	1.9	20
ABS PVC window with 5 or 6 chambers and double IZO LOW-E glass	1.2	13
ABS PVC with 6 Protect Termo+ chambers and triple IZO LOW-E glass	0.7	7

By analyzing Table 2, we can conclude that new generations of windows have lower Uw values, which contributes to the energy efficiency of buildings. The U_w value depends on many factors, including the type of glass, the number and type of glass layers, the thickness of the window hardware, and the presence of additional thermal breaks or coatings on the glass. The lower the Uw value, the better the insulation of the windows, and the less heat will pass through them.

Table 3. Value of heat transfer coefficient in relation to spacer material [3].

	A TYPE OF PROFILE SPACER	VALUE $\sum(d_i x \gamma_i)$
1	ALUMINUM	0,1120
2	STAINLESS STEEL	0,0052
3	CHROMATECH ULTRA STAINLESS STEEL	0,0026
4	THERMO TGI	0,0020

Table 3 shows the value of the heat transfer coefficient to the type and material of the spacer. The table shows that the aluminum spacer profile is the one that loses the most thermal energy.

Tabele 4. Comparison of window frame materials with spacer type and coefficient [3].

	Coefficient P_{si}	Glass construction	Type of window frame	Type of spacer
1	0,065	4/16/4	Plastic	Aluminum
2	0,066	4/12/4/12/4	Plastic	Aluminum
3	0,051	4/16/4	Plastic	Stainless steel
4	0,050	4/12/4/12/4	Plastic	Stainless steel
5	0,040	4/16/4	Plastic	Thermo TGI
6	0,038	4/12/4/12/4	Plastic	Thermo TGI
1	0,071	4/16/4	Wood	Aluminum
2	0,076	4/12/4/12/4	Wood	Aluminum
3	0,053	4/16/4	Wood	Stainless steel
4	0,054	4/12/4/12/4	Wood	Stainless steel
5	0,039	4/16/4	Wood	Thermo TGI
6	0,039	4/12/4/12/4	Wood	Thermo TGI
1	0,080	4/16/4	Aluminum	Aluminum
2	0,110	4/12/4/12/4	Aluminum	Aluminum
3	0,068	4/16/4	Aluminum	Stainless steel
4	0,066	4/12/4/12/4	Aluminum	Stainless steel
5	0,049	4/16/4	Aluminum	Thermo TGI
6	0,044	4/12/4/12/4	Aluminum	Thermo TGI

The analysis in Table 4 shows the difference in the material of the window frame and the difference in the material of the spacer, which affects the passage of heat through the window glass.

Very often, windows can be a source of heat energy losses, which depends on the outside temperatures and environmental conditions. To achieve this balanced composition of heat both in summer and in winter, it is necessary to pay attention to some details when choosing windows. Significantly high-quality window insulation, the joints between the frame and the window, affects the potential losses of thermal energy. The use of special coatings on the glass can significantly reduce the passage of heat through the windows.

By using low-emissivity coatings that reflect heat and reduce heat loss in winter, while at the same time allowing light to pass through, they also reduce excessive heating during summer, this is a Low-E coating.

It is important to point out that blinds and curtains are an important factor in the energy efficiency of the building. They can act as a partial heat insulator in the sense that they can help retain or block a certain amount of heat in the space. However, their effectiveness as insulators depends on various factors, whether it is the material they are made of, thickness, density, and their installation in the space. Using blinds in the summer reduces the need for air conditioning or room cooling. They can act as a barrier to heat lost through windows, when they are closed, they can reduce air convection and reduce heat loss to the outside.

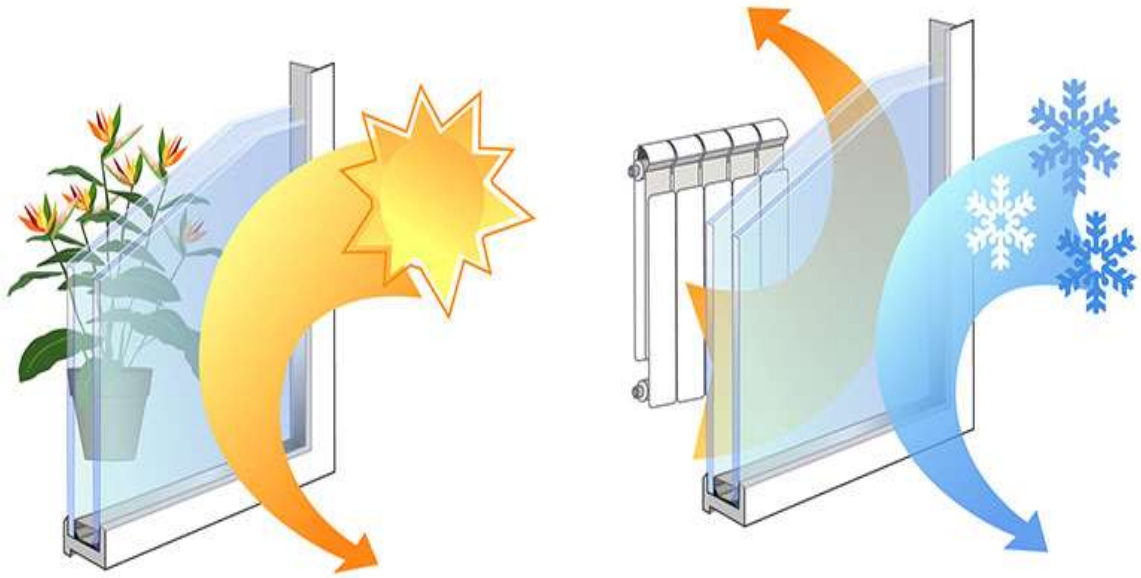

Figure 3. Heat reflection [6].

The thermal properties of aluminum blinds meet the ecological specifications for the proper construction of a passive house. Made of aluminum and filled with polyurethane foam, they simultaneously offer thermal and sound insulation.

Aluminum is a resistant and non-corroded metal that, in combination with a high-quality polyurethane filling, offers thermal protection from the sun and heat in summer, and from wind and cold in winter. [4]

4. Conclusion

A lower value of the *U*w heat transfer coefficient indicates a better insulation of the window and a lower loss of thermal energy. Quality windows are a key factor in the building's energy efficiency, they can significantly reduce the loss of thermal energy during the winter, and reduce heat penetration during the summer. When choosing a window, it is important to consider the *U*w value. Double or triple insulated windows usually have a lower *U*w value, this is due to the presence of a layer of air or gas between the glazed surfaces. As we have to pay attention to the quality of the glass and window frame, we also have to pay attention to the window spacers and their material, as stated above in table 3 and 4, we concluded that aluminum spacers transmit the most heat energy, therefore this aspect should also be paid close attention to .

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Municipal Wastewater Treatment

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Abstract. The production of municipal wastewater, as well as other wastewater from industry, agriculture, etc., is increasing every day, which is largely not purified, but is directly discharged into recipients. This, in addition to climate change, significantly endangers the quality of the environment, often with the consequences of a reduction in water resources associated with a direct threat to human civilization. The European Community noticed this problem a long time ago, so among other things, it passed the Municipal Wastewater Treatment Directive No. 91/271/EEC, as a basis for the protection of all water. The basic goal of the Directive is to protect the environment from the negative effects of wastewater discharges, with the application of appropriate effluent standards/quantity and quality of wastewater. Depending on the sensitivity of the subject area, above all the urban environment, municipal wastewater treatment can be mechanical, biological, chemical, etc., as well as treatment and high-quality disposal of sludge. The purification process takes place in complex hydro construction facilities, the maintenance of which must be ensured in all normal weather conditions.

1. Introduction

Living and working man produces various pollutions of liquid and solid origin. When it comes to purifying polluted water, our goal is to neutralize its harmful effects and dispose of it safely, so that the quality of the human environment, and above all the water sphere, is not compromised. Collected polluted water (influent) is transported as quickly as possible to the place of treatment, i.e. disposal, through suitable sewage facilities - sewers, and discharged into the appropriate recipient (receiver).

In order to successfully perform the task of purifying polluted water, it is necessary to know its quantity, type and quality, methods and processes of purification, and the conditions of the recipient. Purified polluted water (effluent) can also have a secondary use value, so it can be partially or completely (rarely) used in industry, agriculture, and even for filling underground water reserves that serve as springs for the population's drinking water supply.

2. Treatment of waste water

Treatment of waste water is one of the measures to protect water from pollution, but also the most expensive, so it should be planned and implemented as part of other protection measures, primarily of a preventive nature. Water protection planning is carried out within the framework of water management, urban planning and ecology. This requires knowledge of water polluters (their

character), basic sources of pollution and their characteristics, general and special issues of water protection from pollution, etc.

The methods of purifying polluted water include, similarly to the preparation of drinking water, a series of processes and operations that are combined within the technological procedure, often with the application of special - additional actions, which make the purification of polluted water a very expensive and difficult job. For these reasons, the purification of polluted water should be solved in close connection with natural purification, which takes place in nature every day, in order to make the most of the auto-purification power of selected recipients.

In the practice of purifying polluted water, mechanical and biological purification is most often used, and sometimes chemical, including effluent disinfection. Chemical processes are especially present in the purification of polluted industrial waters. A special problem is the treatment of sludge (a process much more complex than in the case of drinking water conditioning), its separation from the liquid phase, thickening, dehydration, neutralization and disposal.

Purification of polluted water is most often carried out in plants (rarely in natural conditions), - a complex set of constructions in which appropriate equipment, devices and automatics are placed, the functioning of which requires the appropriate consumption of energy (most often electrical), various chemicals, and qualified staff for plant management and plant exploitation.

3. Mechanical purification

Undissolved substances, as well as some of the substances in a colloidal state, are removed from polluted waters by a mechanical or physical purification process. The basic task of the mechanical purification of polluted water consists in preventing the stoppage of the operation of the following plant facilities, their overloading and low productivity. In mechanical purification, we distinguish between preliminary and primary purification.

3.1 Preliminary purification

Preliminary purification, as the first stage of mechanical purification, aims to remove coarse ingredients that can clog or damage pumping devices, adversely affect other stages of purification, and damage the aesthetic appearance of the water recipient.

Preliminary purification involves the removal or reduction of large suspended and floating solids (wood, paper, garbage, excreta, etc.) with possibly necessary crushing, then the removal of heavier inorganic materials (sand, gravel, metal parts, glass, etc.), as well as removal of excessive amounts of oil and fat. Also, in this stage of purification, the BOD value is reduced by 5-10%, and the removal of suspended matter by 10-20%.

Coarse and fine grates, crushers, sand clarifiers, pre-aeration basins and fat and oil separators are used for preliminary purification. When a large river or open sea is used as a recipient, then it is sufficient to carry out only preliminary purification, before the final disposal of the effluent. If the recipient is intended for bathing, then, in addition to preliminary cleaning, it is also necessary to carry out disinfection of the effluent.

The layout of facilities for this stage of polluted water treatment is most often in the following order: grate, pumping station, flow meter, sand settler, pre-aeration pool, fat and oil separator.

The flow meter is placed in front of the pumping station, if it works at a constant speed, since the switching on and off of the pumps leads to a flow pulsation that cannot be registered with the most commonly used Parshall type meter.

If variable speed pumps are used, then the Parshall meter can be in front or behind the pump station, since the capacity of the pumps must be identical to the amount of polluted water inflow.

If screw pumps are used, which is the most common case today, at least when it comes to lifting polluted water in front of the plant, then grates can also be placed behind the pumping station.

3.2 Primary purification

The task of primary purification is to remove most of the settleable solids, as well as 40-60% of suspended substances, from the polluted water through the process of sedimentation. By applying

chemicals - coagulants, sedimentation can remove a large part of colloidal substances. Sedimentation is in fact the basic way of purifying polluted waters.

It is based on the fact that the polluted fluid is brought to the pool where the flow rate is reduced, which allows for the separation of suspended particles (with the help of gravity) and their settling on the bottom of the pool. Primary purification lowers the BOD value by about 35%.

If at this stage it is necessary to achieve greater purification effects, then a coagulant is added to the polluted water. In this way, most of the colloidal matter is removed, and the percentage of suspended matter removal increases to around 80-90%, while the BOD value is reduced by 35-60%.

The use of coagulant increases the operating costs of the plant, so its seasonal use is practiced when a higher degree of purification of polluted water is required. The most commonly used facilities for sedimentation are: septic tanks, two-story tanks (Imhoff) and primary clarifiers. Septic tanks and two-story tanks are used for smaller amounts of polluted water.

When using chemicals, auxiliary facilities (devices) are used, such as: dispensers, mixers and flocculators. In most cases, after the stage of primary purification, the effluent can be discharged into receiving recipient, without major danger to its quality (which is not a rule). At modern larger plants for purifying polluted water, where anaerobic stabilization of sludge is carried out, only the so-called primary clarifiers with sludge separation are used. If there are not enough precipitable substances in the polluted water that can settle without the addition of flocculants, then primary settling tanks are not built. The above determinations are made on the basis of established results of the sedimentation analysis of polluted water.

4. Biological purification

Biological or secondary purification of polluted water aims to remove biologically degradable organic matter as much as possible. The reason for this is that in a number of cases, with mechanical (preliminary and primary) purification, we are not able to meet the conditions set by the water authority regarding the protection of water from pollution, because the obtained effluent after the first stage of purification still contains a large part of biodegradable substances (in dissolved and colloidal form) and an excessive amount of suspended matter.

In the stage of biological purification, depending on the efficiency of individual facilities, it is possible to achieve a reduction of the BOD of polluted water in the range of 35 - 95%.

Biological purification processes are based on aerobic decomposition or oxidation of organic matter, as well as on anaerobic decomposition.

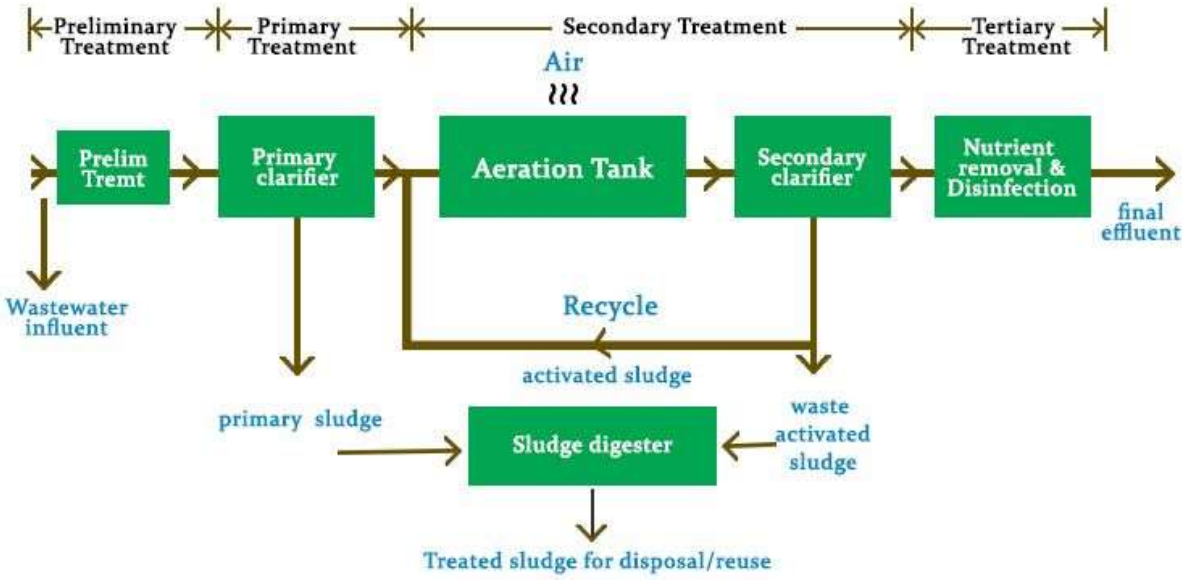

Figure 1. Biological Treatment of Wastewater [6].

By including the living world - microorganisms, the purification effect in terms of reducing the content of biodegradable substances, as well as suspended substances, is significantly improved. Moreover, a high degree of purification can primarily be achieved by using a biological purification phase.

Biological purification of smaller quantities of polluted water can be done in natural or semi-technical conditions, while larger quantities of water are purified in artificial or technical conditions. Facilities where biological treatment is performed are: percolation biofilters, facilities with activated sludge, sand filters (filtration fields) and stabilization lagoons (channels).

For the biological purification of polluted water (if there are no interfering and toxic ingredients) in aerobic conditions, a large surface area is required for the transfer of oxygen and the introduction of a large amount of air (oxygen).

Under semi-technical conditions (almost natural), large areas of land, i.e. large areas of shallow pools (lagoons) are used to ensure the introduction of oxygen. In artificially formed conditions, a large area is provided through two different processes: biological filtration and activated sludge.

In the case of biological filters, a large area is provided by the surface of the filter medium, through which the polluted water flows, and the supply of oxygen is achieved by a draft or air blowing.

In the process with activated sludge (bioaeration basins), the surface is created through the formed mass of sludge flakes - activated sludge, and oxygen is introduced by blowing or mechanically changing the mass of polluted water in direct contact with air.

The lack of semi-technical procedures (use of polluted water for irrigation, various forms of soil filtration, ponds, lagoons, etc.) is due to the fact that they cannot work throughout the year, since agricultural crops use water only in certain periods of time (e.g. ponds are empty in winter).

5. Plants for purifying polluted water

Plants for purifying polluted water represent a series of facilities and devices in which polluted water is subjected to purification processes in accordance with the required criteria. Purification processes take place through several stages - procedures, according to the designed technological scheme and the calculation made on the basis of the input parameters of polluted water, and the conditions provided by the selected recipient, i.e. local conditions.

The final adoption of plant capacity and technological purification process are preceded by consideration of alternative solutions according to purification needs, analysis of local conditions of the urban area, as well as techno-economic calculation. The selected purification process determines the choice of facilities and devices, followed by the selection of the location of the plant, the design of the layout scheme of the plant, the definitive hydraulic calculation, the choice of equipment, architectural and construction design, the definition of the working staff and their working conditions, the conditions of construction and operation of the plant, the safety conditions at work, etc.

6. Plant operation/exploitation

For the successful exploitation of the polluted water treatment plant, it is very important to make regular observations of changes in the flow and quality of the polluted water, both at the entrance to the plant and between individual buildings, and at the exit from the plant. The quantities of polluted water at different points of the plant are determined by the capacity of the pumps or by installed overflows and special meters. Sampling for the analysis of the quality of the liquid phase and sludge should be coordinated with the observation (measurement) of the flow in order to make corrections as correctly as possible in the management of the purification process of the overall plant and its individual units and facilities.

At larger plants, it is necessary to have a suitable laboratory where it will be possible to analyze data on the concentration of suspended and settling substances, BOD, pH, the amount of coliform bacteria and residual chlorine. If the plant treats mixed polluted water, the laboratory should have equipment for the analysis of COD, phosphate content, various forms of nitrogen, sulfides, gases, acidity and basicity of water and sludge, grease, heavy metals, etc.

Figure 2. Wastewater plant in Bihać [5].

The specialist in charge of the operation of the plant must have a good knowledge of the principles and scope of work of each aggregate and its role in the general purification process. The characteristics of the influent in terms of quantity and quality should also include indicators of industrially polluted water, as well as data on the amount of water infiltration and exfiltration. In order to meet the set criteria on the effects of purification, the person in charge at the plant regularly controls the results of the effects with valid standards for polluted water, effluent and recipient water.
The operation of the plant is also monitored from the aspect of planned exploitation costs, and correction is made in relation to the data from the project documentation.

The degree of removal of organic matter (in %) is traditionally calculated by comparing the concentration by BOD and suspended matter in the influent and effluent.

The relationship between BOD and suspended matter or the organic part of suspended matter in the influent is an important parameter for determining the effect of primary sedimentation. It can be assumed that simple retention (sedimentation) will be effective if the concentration of suspended matter and BOD is in an approximate ratio of 1:1. Likewise, if the content of dissolved organic matter (i.e. BOD) is several times higher than the content of suspended organic matter, then the greater part of organic matter will be removed during biological purification, and not by primary sedimentation. Sludge, obtained from the purification process, also provides elements of the efficiency of the operation of the purification plant. The economic aspect of the sludge disposal problem is directly related to dehydration. An overabundance of moisture in the sludge can lead to the increase in the cost of sludge transportation during incineration, additional costs for fuel, etc.

The basic indicator that must be studied when determining the efficiency of biological treatment is the degree of removal of organic matter and the characteristics of excess activated sludge. Evaluating the results of secondary treatment only by the measure of BOD reduction and the concentration of suspended matter would be to ignore sludge thickening. The addition of waste water, the recirculation of activated sludge, and the disposal of treated sludge should be regulated in such a way as to obtain as much sludge as possible and preserve the high quality of the effluent. The functioning of aeration systems at different concentrations of dissolved oxygen and suspended matter in the mixed fluid, and different ratio - organic substance/microorganisms, can, during the serious implementation of control analyses, affect the achievement of optimal conditions of the exploitation mode of the plant.

7. Conclusion

Purification of polluted waters is one of the measures to protect water from pollution, but also the most expensive process, so it shoul be planned and effected within other preventive protection measures. The planning of water protection is done by water resource engineering, through city planning and ecology. This requires a knowledge about water pollutants (their character) the main sources of

pollution and their feature, to know the general and specific problemacy of water protections againts pollutants, etc.

The methods of polluted water purification include, similar to drink water preparation, numerous processes and operations combined within the technological process, frequently by application of special, additional actions, making the polluted water purification very expensive and complex. For these reasons, the polluted water purification has to be solved in tight connection with natural purification, done daily by nature, in order to use maximally the auto-purification power of selected recipients.

For purification of polluted waters in practice, most frequently used are mechanical and biological purifications, sometimes chemical including desinfections of effluents. Chemical procedures are used especially in purufication of polluted industrial waters.

Special problem is the treatment of mud, its extraction from liqued phase, condensation, dehydratation, neutralisation and disposal.

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Protection of the construction pit of an individual residential building in the street Kromolj no.76 in Sarajevo

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Abstract. This paper will give an example of securing a construction pit of a residential building. The residential building is located in the village of Kromolj in Sarajevo. The example given in this paper shows the optimization of a reinforced concrete structure so that the foundation of the retaining structure was used as part of the foundation slab of the building.

1. Introduction

This paper will give an example of securing a construction pit of a residential building. The residential building is located in the village of Kromolj in Sarajevo. The example given in this paper shows the optimization of a reinforced concrete structure so that the foundation of the retaining structure was used as part of the foundation slab of the building.

2. Geotechnical field model

Relevant geo mechanical parameters, taken from the Report [1], were determined in laboratory and field testing conditions. The field model with relevant geo mechanical parameters for calculations is given below.

Geotechnical environment/unit GS1 – eluvia - diluvia cover - clays:
- bulk density ◘ = 18 kN/m^3;
- cohesion c = 5 kN/m^2;
- angle of internal friction ◘ = 12°.

Geotechnical environment/unit GS2 - geological substrate - marl:
- bulk density ◘ = 21 kN/m^3;
- cohesion c = 15 kN/m^2;
- angle of internal friction ◘ = 23°.

3. Description of the technical solution

The construction of the object in question is planned on a conditionally stable terrain with a slope of approx. 15 °. Therefore, it is necessary to ensure the local stability of the terrain on which the facility is being built, as well as the stability of the road that passes above the subject plot.

The conceptual design of the building, developed by the project bureau "BLACK AND WHITE" from Sarajevo, envisages the construction of an individual residential building with maximum dimensions of 15.65x10.60 m, floors Basement+Ground floor+1. The building is oriented perpendicular to the isohypses of the terrain.

The formation of the construction pit of the object in question requires cutting the slope in the height of approx. 3.00 m over the entire width of the building (approx. 12.00 m).

To find a technical solution that will ensure the stability of the slope and scarp on the foundation pit made on it, as well as the most economically rational solution, the designers decided to make a reinforced concrete supporting structure that will also be the load-bearing wall of the building.

Wall A-B has the shape of a "⊥" profile [4] along the entire length l = 10.75 m, with a total canvas height of 2.85 m and a thickness of 0.30 m. The wall is based on a reinforced concrete slab 0.30 m thick, the width of the part of the slab towards the slope 0.75 m and the part of the slab towards the building is 1.00 m wide. A reinforced concrete wall slab is an integral part of the counter slab on which the building is based, and the wall canvas is also the basement wall of the building.

In front of the wall, from the side towards the hill, a drainage PEHD SN4 pipe Ø 150 mm 15.00 m long (from RO1 to RO2) is laid, and manholes are installed.

The space between the wall and the scarp excavation is filled with filter material of the prescribed granulation in the height of 2.00 m, and crushed stone is backfilled to the required level.

4. Static wall calculation

Static calculation of the walls has been performed in the Geo5 program. The calculation obtained the cross-sectional forces in the wall and the required reinforcement. The wall has been inspected for overturning and sliding. The calculation has been performed for the most critical section of the wall. The calculation was carried out under Euro code 7, PP3 design approach.

Table 1. Euro code 7 – partial safety factors [2].

Project approach	The impact and effects of influence	Soil Resistance
GEO DA3	$\gamma_G = 1{,}00$; $\gamma_Q = 1{,}30$	$\gamma_\varphi = \gamma_c = 1{,}25$; $\gamma_{cu} = 1{,}4$

The adopted water level used in the calculation is 0.5 m above the upper surface of the foundation, i.e., at the elevation of the drainage pipe behind the wall.

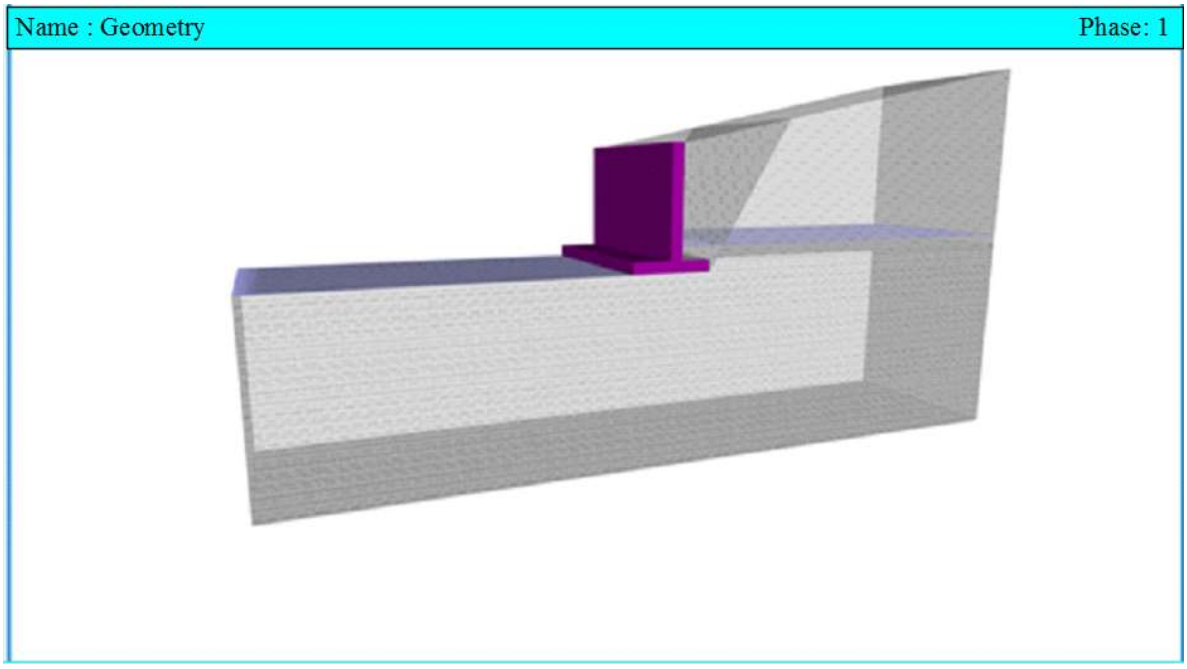

Figure 1. The Geometry of the Wall.

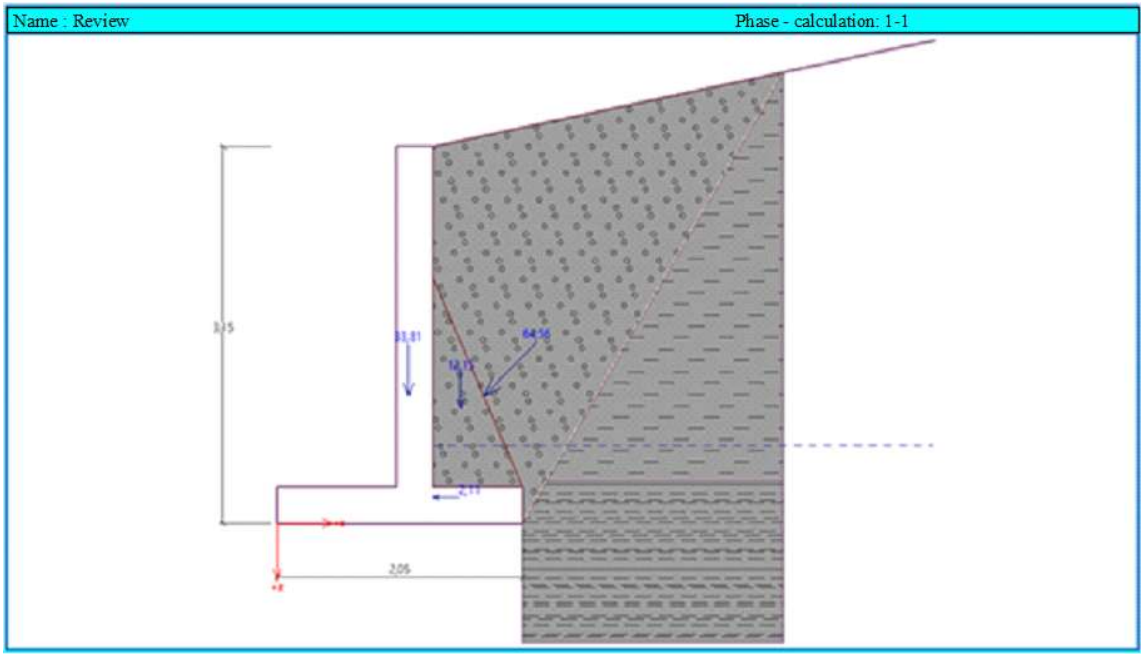

Figure 2. Wall overturning and sliding control.

Verification/control of the whole wall
Overturning stability check
Moment of Resistance M_{res} = 136,0 kNm/m
Moment of Overturning M_{ovr} = 48,24 kNm/m
Overturning wall SATISFACTORY
Sliding check
Horizontal force of resistance H_{res} = 54,17 kN/m
Horizontal force of action H_{act} = 47,00 kN/m
Wall for Sliding SATISFACTORY
Overall Check - Wall SATISFACTORY
Maximum stress at the bottom of the foundation: 53,89 kPa

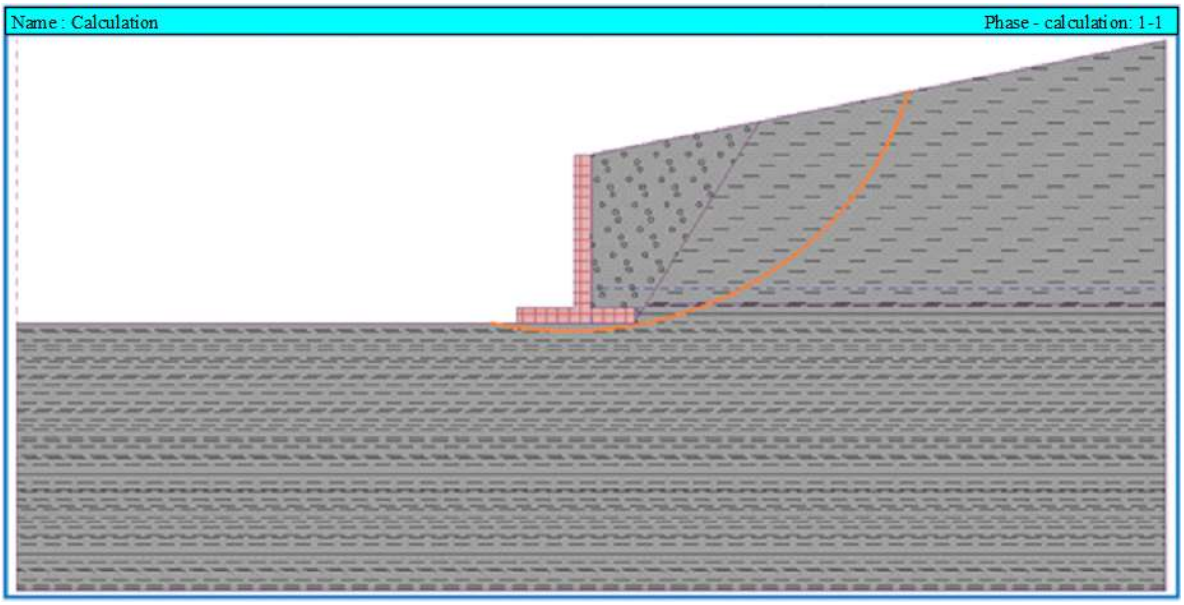

Figure 3. Slope stability calculation.

Slope stability check (Janbu)
Usability: 81, 5%.
Slope stability ACCEPTABLE

5. Execution condition

The subject technical conditions can be supplemented or changed during the works themselves, but within the framework provided by this project and in agreement with the Designer and the Investor. When performing the works, the Contractor is obliged to comply with all technical documentation, drawings, instructions and budgets, and perform the works according to the description of the cost items, technical regulations and norms, and applicable standards. Subject papers can roughly be divided into:

- Preparatory works;
- Geodetic works - staking out the structure;
- Excavation works;
- Concrete and reinforcement works - construction of a retaining wall;
- Material quality control.

Preparatory works include preparing the terrain for geodetic staking. Before starting the works, it is necessary to stake out the points, positionally and vertically. The accuracy of staking should be within the limits of ±0.5 cm (height and position), and during the performance it is necessary to constantly control the staking.

Excavation work begins after the completion of preparatory work, especially geodetic staking. The terrain is cleaned, access to the location is secured, and after that the excavation work can begin.

All excavations should be carried out in camps with a maximum length of 6.00 m, by the given drawings and instructions of the authorized engineer - geo technician. The actual length of one camp will be determined by field supervision during the execution of works, by adapting to the situation on the ground. Excavations must not be left open for a long period of time but must be secured immediately after completion with a designed reinforced concrete supporting structure.

During the execution of works, provide constant design supervision.

Spread sub base material in a layer of approx. 5 cm and compact the same with a vibratory plate. Immediately after that, mount the slab reinforcement and concrete it with MB30 concrete. After concreting the wall canvas and removing the formwork, make a concrete flume at a slope of 1% towards the manhole RO2 and cover the excavation scarp with geo textile. A drainage PEHD SN4 pipe Ø 150 mm, 15.00 m long (from RO1 to RO2) is installed on the wall slab (on the uphill side). Fill the drainage pipe with filter material to a height determined by the supervisory authority (depending on the length of time from concreting to backfilling), so as not to jeopardize the recently concreted wall structure.

Excavation work on the next camp can only begin after all work on the previous camp has been completed.

Above the filter material, a crushed stone with a maximum grain size of 150 mm and a maximum of 5% of clay particles is backfilled. Filling of filter material and crushed stone need to be done in layers of approx. 30 cm with compaction by mechanical compaction means.

After excavation for the foundations, it is necessary to immediately install the already prepared reinforcement and carry out concreting of the foundation of the wall. Only after that, the performance of the ab canvas is approached.

This Project provides only the reinforcement of the retaining wall. All anchors for the connection of the retaining wall with the other walls of the basement and ground floor, which are installed in the retaining wall, will be provided in the main project of the residential building.

The formwork must be continuous so that it can receive the loads and impacts that occur during the execution of the works.

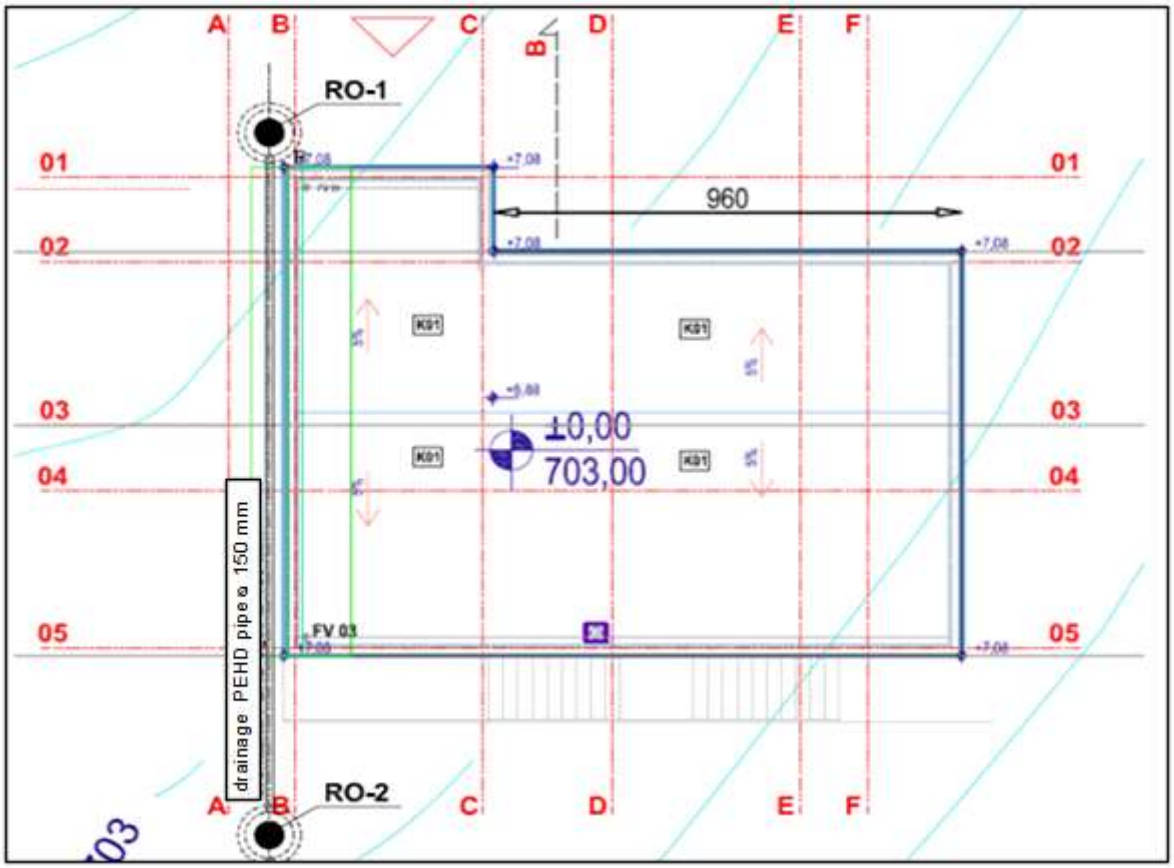

Figure 4. The situational layout of the terrain with marked retaining construction [3].

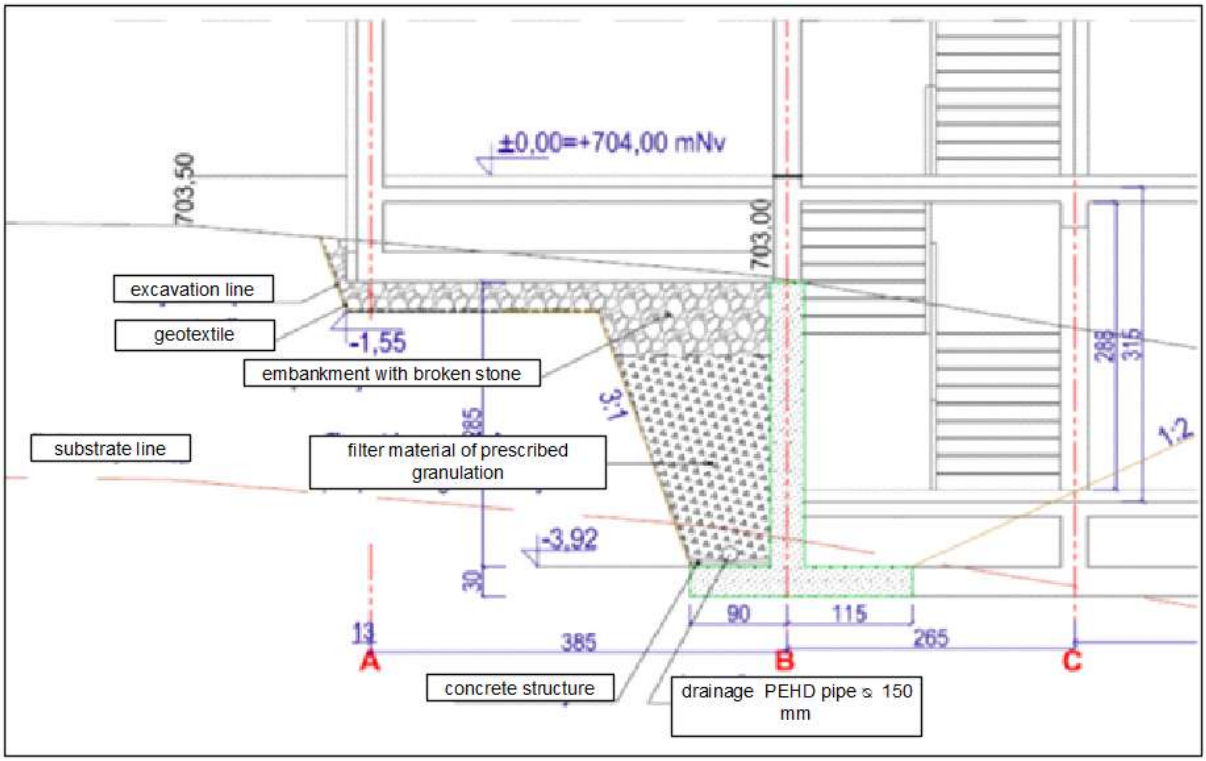

Figure 5. Terrain cross-section [3].

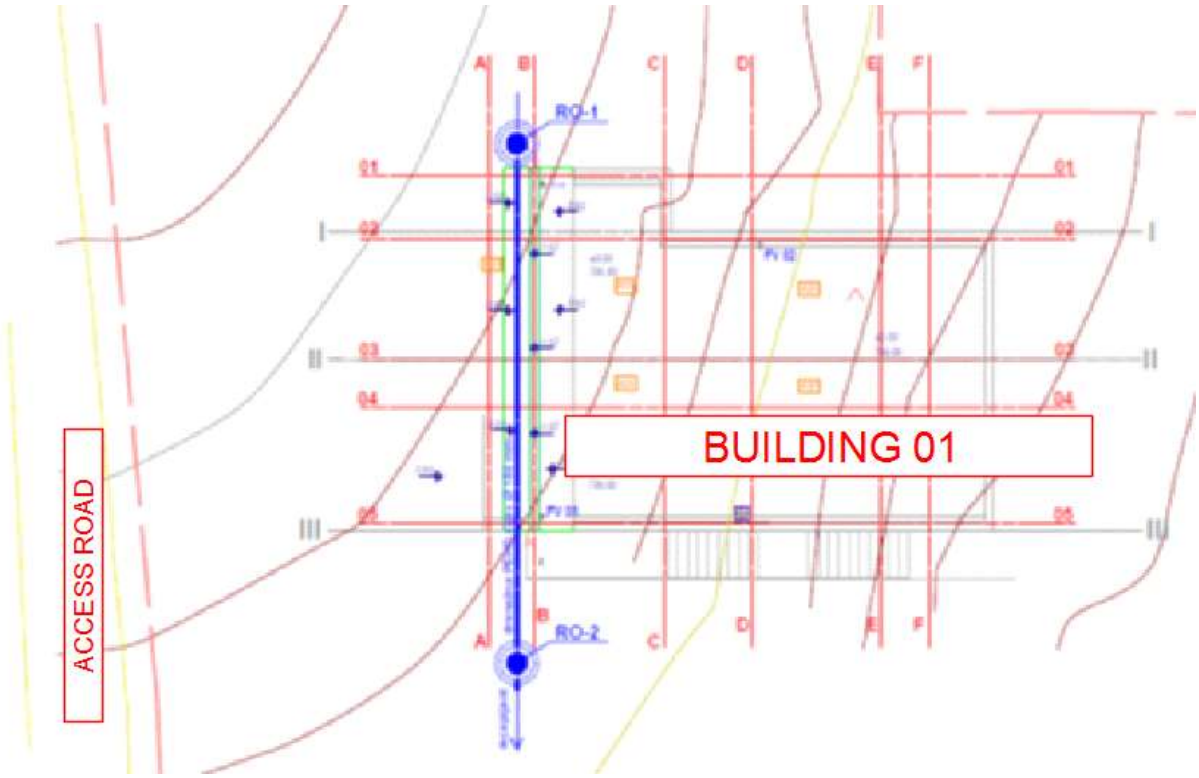

Figure 5. Situational plan of the road and the building [3].

6. Conclusion

This paper presents an example of securing a construction pit of a residential building. The residential building is located in the village of Kromolj in Sarajevo. The example given in this paper shows the optimization of a reinforced concrete structure so that the foundation of the retaining structure is used as part of the foundation slab of the building.

In this way, the safety of the retaining structure is achieved together with the optimization of construction costs.

This kind of securing of the excavation ensures the stability of the foundation pit and safe work in it, and prevents damage to the road. By building a support structure, maximum safety is achieved. The cost of these works is high, but in addition to safe work, it also ensures undisturbed passage and traffic.

Any other solution would require larger excavations, but safety would be significantly lower and there could be damage to the road and disruption of traffic on it.

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Digital fashion innovation and sustainability

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Abstract. The digital transformation of the fashion industry has gradually led to the implementation of new sustainable business models and concepts which enable faster and easier adaptation to the market changes and increase business efficiency. A paradigm shift to mass customization has become an imperative for many companies to survive in an increasingly diverse, fragmented and competitive market. The intensive development of specialized digital technologies integrated with software systems opens up new opportunities for the process of design and clothing development. The simultanious development of social media and digital platforms integrated with augmented and virtual reality technologies, opens up possibilities for transformation of entire fashion supply chain, from the creative segment of digital design and virtual clothing development according to customer targeted requirements, up to sustainable concepts of sales promotion and virtual environment consumerism. The paper presents the analysis of digital technologies and specialized computer systems possibilities and impact in the field of fashion design, development of digital clothing fashion collections and the potential of their future presentation in the metaverse as an interoperable network of virtual 3D worlds. The possibilities that the implementation of augmented and virtual reality in the future can have on the entire fashion industry supply chain have been explored. The possibilities of the virtual clothing fashion collections development are presented in response to the growing fashion industry demands and the new virtual market that is current, attractive, sustainable and completely digital.

1. Introduction

The speed of new collection development and the frequent change of fashion trends stand out as the main characteristics of the 21st century fashion industry, while the globalization and new communication technologies have implied that fashion has become faster and cheaper. Leading fashion houses over the years have only increased the production of their collections (haute couture, pret-a-porter, pre-fall, cruise, resort, capsule, etc.) in response to the current information of today [1]. In this context, the company's competitiveness highly depends on flexibility and the ability to quickly respond to market demands, whereby the need for quality management of digitalization, sustainability and supply chain requirements is increasingly highlighted [2]. The Covid-19 pandemic significantly accelerated the transition to online business and online sales of fashion products. However, due to the globally reduced need to buy clothes in the past three-year period, stocks of unsold clothes that need to be stored or disposed of somewhere have been created. In this context, the fashion industry, which is at the very top of the industry whose activity has an unfavorable impact on the environment, faces a great responsibility in terms of properly disposing of excess clothing and introducing sustainable business concepts, related to the range of clothing and supply chains and the complete digitization of the development process,

production and sales. Therefore, it is very important to choose methods to predict future fashion trends and products for which there will be demand [3]. At the same time, further investment in digital technologies is extremely important as it opens up a new level of unique options for fashion brands, suppliers and consumers [4-6]. Although there is not yet a consensus on the relationship between sustainability and technology, as digital technologies cannot solve all the problems of the fashion industry in the context of sustainability, the positive effect of digitalization in the design and development of fashion products and the transformation of supply chains into sustainable systems is undeniable [7]. Digital clothing and the development of computer systems for 3D design and the development of clothing models have recently seen significant new growth, to which the unfavorable epidemiological situation worldwide in the last three years has contributed, as well as the needs of new generations, users of social networks and digital platforms. The spread of digital fashion is not limited to the development and implementation of CAD (Computer Aided Design) systems in product design and development processes and CAM (Computer Aided Manufacturing) systems in apparel production processes, but extends to all segments of the fashion business, from product lifecycle management to the development of new business models that promote sustainability to combine virtual and augmented reality with fashion to enhance the consumer experience through intelligent solutions [8,9]. In this context, digital technologies become an indispensable tool in the rapid development of collections of new clothing models, but also open the possibility for new forms of sustainable development of clothing models according to customer requirements and the development of completely new models of digital advertising and sales of fashion products, Figure 1.

In addition to the needs of the fashion and clothing industry, digital clothing is increasingly being developed and is the subject of research in the growing gaming industry [10,11], and other creative industries. This opens a new direction of future research in the field of computer design and development of digital clothing models in an interdisciplinary field where clothing engineering has not been represented before and which is estimated to be able to achieve a significant contribution, especially in the context of digitalization and sustainable fashion [12]. Also, digital platforms are gradually being developed through which 3D clothing models are integrated into online stores and brand value is transferred into the digital proctor and metaverse, and VR technologies significantly improve user interaction in the context of realistic viewing of models [13-16]. In this context, digital apparel development involves interdisciplinary research that intersects the interests of researchers and experts in the field of digital design and product development, anthropometrics, computer science, development in the field of gaming, film, and other creative industries, business and technology, supply chain management and Industry 4.0, artificial intelligence and sustainable industry development.

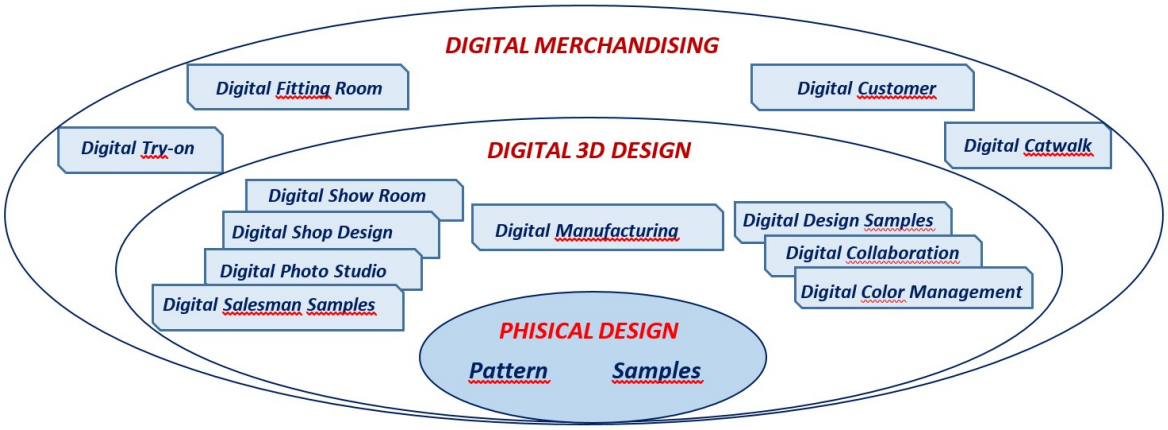


Figure 1. Digitalization of the modern fashion supply chain.

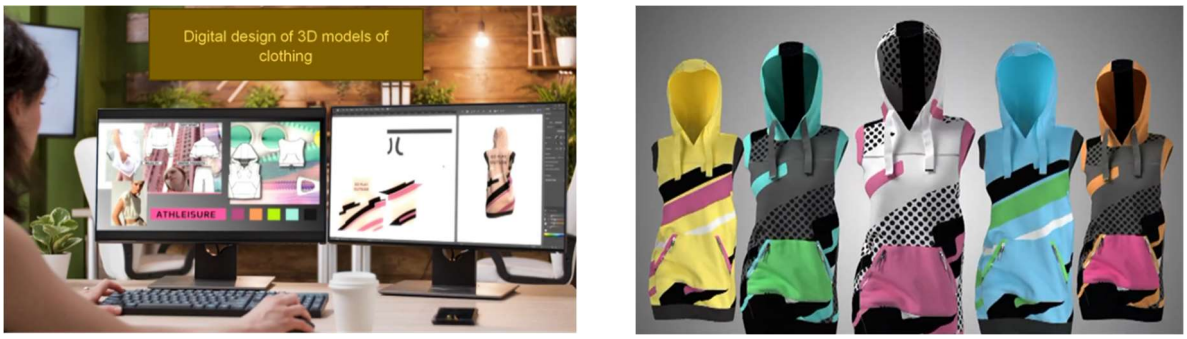
The paper reviews the development achievements and innovations in digital fashion, focusing on the positive changes that digitization of certain segments of the fashion industry supply chain can have on the sustainability of this important industry.

2. Digital fashion design and sustainable development of fashion products

Digitization is visibly present in various aspects of fashion design, which is reflected in the available digital technologies developed specifically for the fashion industry [17-19]. The concept of digitalization implies not only the creation of a new media format, but can be considered more broadly as a process in which conventional processes are digitally upgraded to develop new models, in order to improve processes and increase the competitiveness of companies, but also to ensure sustainability, fair working conditions and environmental protection [20].

The beginnings of the use of personal computers and the development of CAD programs in the late 80s and early 90s of the last century enabled fashion designers to raise creativity in fashion design to a higher level [21,22]. Companies such as Adobe and Corel were founded. Since then, 2D programs Adobe Illustrator and CorelDraw have gradually become popular as digital tools for product and graphic design, and fashion designers have begun to use them extensively. In parallel, specialized CAD systems were developed with program packages for designing textile materials and clothing styles, which enabled significant progress in developing patterns for textile materials and styles in clothing collections [23,24]. Modern CAD systems allow designers to use very sophisticated programs and tools specifically developed for the creation of garment elements that are further used in technical drawings for different garment styles, but also for the creation of a complete technical package as part of the preparation for the production of an individual clothing item. In addition, specialized programs have been developed for the design of fabric, knitting and textile printing patterns, the use of which greatly speeds up and enriches the design process by generating a large number of pattern variations in terms of color combinations, knitting or weaving, and graphic transformations of pattern units [25]. Among the modern CAD systems intended for 2D design of textile materials and/or fashion products, Kaledo by Lectra, Tex-Design by Koppermann, C- DESIGN Fashion by C- DESIGN, etc. stand out. Apparel design involves the development of design sketches, fashion illustrations, and technical drawings. These are complemented by digitally created patterns and textures of textile materials [26-28]. Software packages with databases containing created drawings of garments and garment elements that can be further edited greatly accelerate the development of new technical model drawings as well as the preparation of technical packages for new garment collections.

The term "digital fashion," which has become very relevant in recent years, has a much broader meaning than fashion design in the traditional sense, as well as different meanings in different contexts. Technological innovations are significantly changing the approach to fashion design, from the conventional expression of a fashion designer through 2D drawings of fashion products to a process that combines design and parallel development of new ideas and products using digital technologies and specialized CAD systems, to digital communication with business partners and the presentation and sale of a digital or real fashion product to customers through computer platforms [29].



a) b)

Figure 2. (a) Digital fashion design; (b) Design variations of a digital 3D model of clothing [30].

Visualizing a digital model of a garment with the ability to render it in different variations of colors, patterns, and details using rendering tools allows designers to create a variety of models when proposing new clothing collections, Figure 2. In this way, design ideas can be communicated very clearly within

the development team, marketing and sales departments, and the customers themselves as part of an individualized design. It also opens up the possibility of market research through the presentation of digital apparel collections before actual production, as well as the planning of sustainable production with an assortment of products for which there is demand.

The continuation of the work will explore and describe topics that include digital fashion from the point of view of its development, business and promotion, as well as its implementation in virtual environments and the metaverse.

1.1. CAD systems for the sustainable design and development of clothing prototypes

The beginnings of the application of specialized CAD systems intended for computer-aided design and development of clothing cutting patterns date back to the 80s of the last century [23]. The initially developed programs of the CAD system were focused on digitizing cutting patterns, computer grading, and marker making. Today, with the advancement of computer configurations and programs, modern CAD systems allow complete computer development of patterns, from basic pattern construction or digitizing, pattern modeling and development, preparation for marker making according to industry standards and various users needs, to computer creation, development and analysis of 3D garment models. Among the significant and globally represented manufacturers of specialized two-dimensional (2D) and three-dimensional (3D) CAD systems for the needs of the fashion and apparel industry Lectra, Assyst, Optitex, Browzwear, Clo, GRAFIS, Audaces Apparel, TUKAcad, PAD System and many others stand out, Table 1.

Table 1. List of available 2D and 3D CAD systems for the fashion industry.

2D CAD for design and illustration		**2D CAD for pattern cutting and marker making**		**3D CAD for 3D simulation and visualization**	
System	**Supplier**	**System**	**Supplier**	**System**	**Supplier**
Corel Draw	Corel	PatternMaster	Wild Ginger	Style 3D	Linctex
Illustrator	Adobe	Easy Pattern	GT CAD	CLO 3D	Clo
Weavelt	Canyon Art	Creative STUDIO	Gemini CAD	Modaris 3D	Lectra
Design Dobby/ Jacquard	Textronic	Gerber Accumark 2D	Lectra	TUKA 3D	Tukatech
Kaledo Style	Lectra	Modaris	Lectra	Vstitcher & Lotta	Browzwear
Colorsep, Pro-Weave, Knit	Pointcarre	PDS	Optitex	Gerber AccuMark 3D	Lectra
Tex-Design	Koppermann	TUKAcad	Tukatech	3D Vidya	Assyst
TUKAstudio	TUKATECH	Telestia Creator	SITAM-AB	Tailornova 3D	Tailornova
Digital Fashion Pro	Digital Fashion Pro	Pattern Smith	Automatrix	3D Mapping	Pointcarre
		PAD pattern design	Pad System	Design 3D	Textronic
		Tailornova	Tailornova		
		Pattern Xpert	Style CAD		

The software packages intended for computer design and development of patterns and creation of 3D models of garments differ in sophistication, but generally contribute to a much faster development of new clothing collections. In doing so, it is possible to develop and analyze the shape of the model and the fit for different types of textile materials, test and, if necessary, adjust the design and pattern pieces for target sizes of garments, eliminating the need to produce a large number of test samples before production [31,32]. This also reduces costs, consumption of materials and energy sources, and thus the negative impact on the environment. Secondly, communication within the development team during production preparation, as well as with customers and business partners in connection with the production of individualized clothing, the release of new models for collections, and the global communication and e-commerrce of clothing and other fashion products, has been greatly facilitated and accelerated.

1.2. Creation and development of a digital fashion product

Digital Product Creation – DPC in the context of fashion product and prototype development has been the focus of research for more than two decades and in recent years also the focus of investment programs in the fashion industry. It does not only refer to the replacement of the physical sampling new models in the development segment, but is already having a much greater impact on redefining the fashion industry. The creation of digital representations of fashion products and the creation of digital assets influences the making of creative and commercial decisions, and there is almost no phase of the value chain where the importance of a digital fashion product is not recognized. An even greater significance of the creation of digital fashion products, key to achieving the strategic goals of fashion brands, is expected in the coming years, given the new approaches in the design area as well as 3D simulation, virtual model fitting and product visualization, aimed at e-commerce [29,33].

Although CAD systems for the digital development of 3D apparel models have been continuously developed for more than two decades, and the system's tools and capabilities have been improved according to the specific needs of fashion designers and apparel developers, for many years there has been resistance from most fashion brands to adopt new technologies and introduce new business models that involve the full development of a digital fashion product. The complexity of the processes, the lack of information and/or financial resources to invest in expensive equipment, the lack of educated staff, the lack of efficiency or confidence in the accuracy and/or usefulness of implementing specialized CAD systems for digital product development, as well as the generally slow digitization of business processes have hampered the very gradual introduction of these systems in the development segments of more significant and globally competitive fashion brands.

Figure 3. Creating a 3D digital fashion product [30].

Given the extreme acceleration of digitization at a global level, the development of the Internet, communication channels and platforms, the expansion of business in marketing and sales to social networks, the opportunities and profitability that digital fashion products bring to other creative industries, and policies and guidelines enacted at the global level related to sustainable development and

reducing the negative environmental impact of the textile and fashion industry, interest in implementing technologies, systems, and platforms that enable the development, use, and sale of digital fashion products is growing intensely among fashion brands, fashion product buyers, experts, and educators in various creative industries and fields of research and development. The creation of a digital fashion product or a 3D model of a garment combines the design and development process into a process of full 2D/3D design and compliance analysis of the model, requiring engineering thinking and an analytical approach in all development steps during the creation and development of a new model, Figure 3.

DPC is a process that uses advanced technology to conceptualize, design, develop and manufacture 3D products in a virtual, collaborative environment. It offers an environmentally friendly and cost-effective alternative through material digitization, 3D pattern simulation, and 3D assets. The parallel use of a program for 2D cutting patterns development and a program for performing a 3D simulation of a digital garment model enables the simulation of the 2D pattern pieces joining and a realistic representation of the virtual garment on a computer 3D model of the human body with a certain anthropometric characteristics. The development of a 3D digital model of a garment aims at the creation of a digital prototype on which the elements of the model and the different phases of work are analyzed and evaluated:

- realistic visualization and analysis of the model design before making the actual sample,
- analysis of the accuracy and precision of the garment model construction and pattern modeling,
- analysis of the fit of the given clothing size on a 3D computer body model, which is adjusted in measurements to the selected clothing size or individual measurements,
- analysis of the fit and achievement of the desired 3D shape of the clothing model from the aspect of the proper selection of textile materials with different physical and mechanical properties,
- analysis of the wearing comfort of the garment model and its dimensions according to the dimensional specifications,
- analysis of stress and elongation of the simulated 3D model of the garment on the 3D body model from the aspect of the proper selection of textile materials with different physical and mechanical properties and evaluation of the garment model functionality,
- analysis of the fit and appropriateness of a given model for different body types and sizes as a basis for planning the pattern grading in the appropriate range of the garment sizes
- analysis of the clothing model from the aspect of selection of colors, textures, decorative seams, details, etc.
- analysis of the complexity of the garment model as a starting point for creating a plan for technological operations and an assembly plan for industrial production.

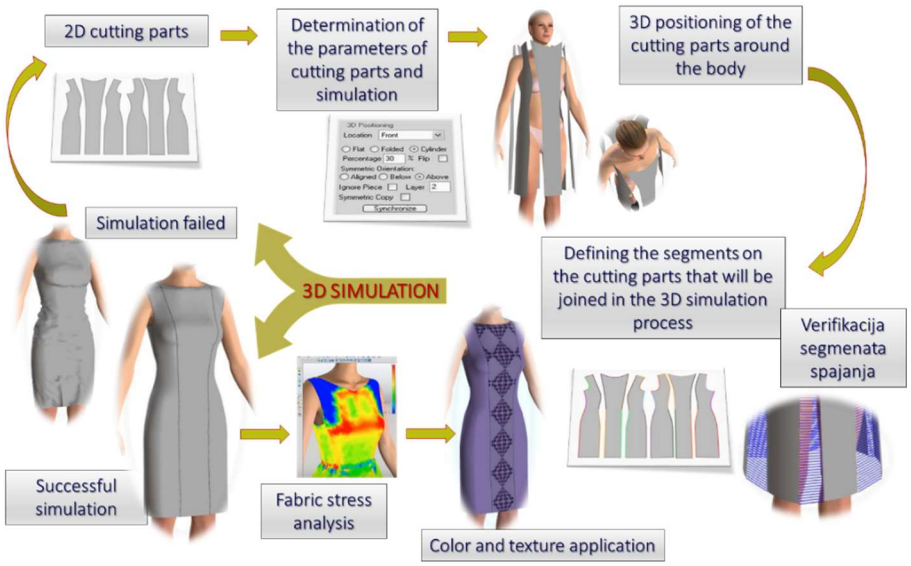


Figure 4. Process cycle of the development and 3D simulation of a digital clothing model.

The process cycle of 3D simulation of a garment model refers to the sequence of procedures in which all the required data are determined and the values of certain parameters are defined and/or specifically adjusted to transform the computer-modeled 2D pattern of the garment into a 3D digital model prototype, Figure 4.

Computer-aided design and development of 3D digital prototypes of the model significantly speeds up the development process, and any deficiencies identified during computer analysis of the model can be corrected before the actual test sample is produced. In this sense, the process cycle of 3D simulation of the garment model can be repeated as needed until all defects on the prototype model are corrected [29,33]. The success of 3D prototype model simulation depends on a number of parameters and requires the application of new knowledge and skills based on scientific and research knowledge, a creative approach and a systematic combination of knowledge from different fields.

1.3. Digitization of textile materials

In order to assign natural physical properties to the digital garment, which are characteristic for the simulation of textile materials in the CAD systems 3D programs, physical simulation is used as an element of virtual environment simulation. This simulates the behavior during a collision, i.e. the collision between the 3D body model and the textile material assigned to the cutting parts of the garment, as well as the behavior between the layers of the textile material. The simulation of the garment model is influenced by numerous factors on which the final result depends, i.e. a more or less realistic 3D representation of the garment. It is of great importance to choose an appropriate physical model, then manipulate the interaction between particles, i.e. polygon vertices in a mesh simulating the surface of the garment model, check the collision detection for each particle and the effect of internal or external forces [34]. To simulate the properties of different textile materials as realistically as possible, computer graphics programs have implemented algorithms that calculate the position and shape of the textile material on the virtual scene, i.e., on the virtual prototype of the clothing model. The algorithms of the program also take into account the assigned physical and mechanical properties of the simulated textile material, which are previously determined by measurement on specialized systems for objective evaluation of textile materials, such as FAST (eng. Fabric Assurance by Simple Testing) and KES (eng. Kawabata Evaluation System) measurement systems [35], but also some newer ones developed specifically for measuring the properties of textile materials for simulation purposes in a particular CAD system [36].

Numerous researches and studies in the field of nonlinear mechanical properties of textiles in the range of low stresses have turned the subjective evaluation of quality and properties into an objective evaluation of textile materials in the last three decades. The complex behavior of textile materials and the way different materials deform, have been the subject of scientific research around the world for more than three decades, during which many methods and technologies have been developed that allow realistic simulation of the textile materials behavior [37, 38].

However, considering the complexity of the process and the need for additional, very expensive equipment for the objective evaluation of the textile materials properties, the reasons for the very slow implementation of the CAD system for the digital development of 3D fashion products in the industry can also be seen from the issue of determining the materials properties in the simulation system, considering the importance of the materials selection for the evaluation of the garment model fit and thus for the verification of the computer prototype.

The innovative approach to the digitization of textiles is based on the scanning of textiles and the application of an artificial intelligence-based system that allows the scanned image of the material to be converted into a 3D form, suitable for use in the process of simulating a digital fashion product, but also on a much larger scale with the various stakeholders in the supply chain. Frontier.cool Inc. is an example of a company that has developed a digital platform for textile materials [39]. Their platform allows brands to communicate and collaborate with suppliers to manage digital fabric sourcing and reduce time to market. Suppliers (fabric and apparel manufacturers) use Frontier to build their virtual fabric libraries and save on sampling, shipping and other costs associated with production. After scanning a phisical fabric sample, Frontier 3D Fabric Creator, which is based on machine learning technology, converts 2D images of fabric samples into 3D digital material. In addition, the Lasagna system, developed with

advanced machine learning technology, analyzes digital fabrics layer by layer and then quickly generates 3D fabric layers that can be saved as U3M or Zfab files, suitable for use on CAD systems for 3D simulation of a fashion product, such as. Clo 3D, Optitex, Browzwear and others, achieving the realistic behavior of digital fabrics within the CAD system, Figure 5. In addition to creating a 3D digital sample of the textile material, it is possible to generate metadata that includes the specification of the material and its physical and mechanical properties, prices, inventory, etc. Data on the environmental impact of specific materials is also generated, enabling designers and development engineers to make decisions on the selection of environmentally friendly materials.

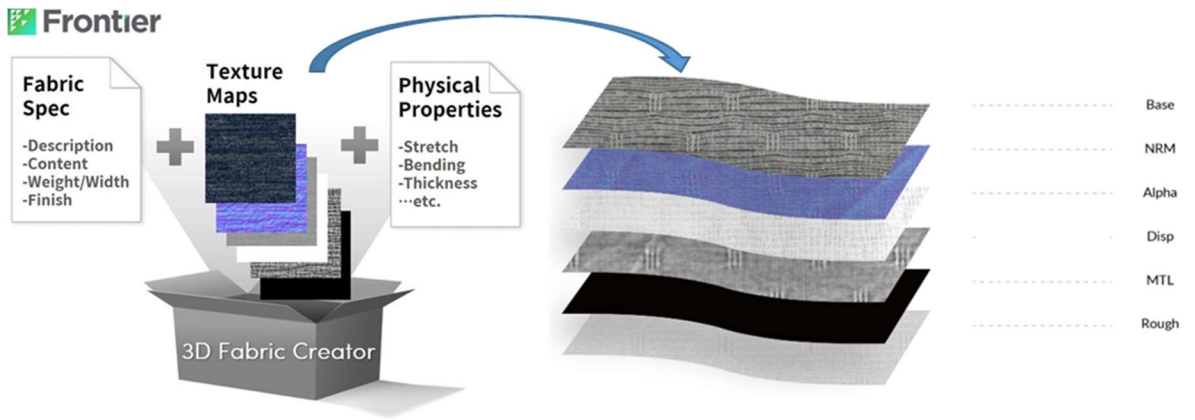


Figure 5. Digitization of textile materials based on machine learning [39].

The process of creating a digital product also has a digital workflow, and in the design and development phase of the model, the time is significantly reduced. With the digitization of textile materials, the material development time is reduced from 3 to 5 months in the traditional process to just three days, while the digitized materials are available to users on a global level in the same time. This also eliminates the waiting time for presenting new materials at trade shows and sourcing new materials for future collections, making it much easier and faster for fashion brands and suppliers to do business with textile materials suppliers. The TextileCloud™ platform allows users to access a digital database of textile samples, where using a 3D viewer to view 3D fabrics can facilitate and speed up material selection for a particular fashion product.

Figure 6. TextileCloud™ platform for the digitization of textile materials [39].

This strengthens the development of a digital fashion product by providing metadata for each digital textile material, which is important not only for the development sector but also for e-commerce of fashion products, PLM systems, and AR and VR, Figure 6.

3. Digital fashion in the virtual reality system and e-commerce

The digital fashion business has developed intensively in recent years, adapting to business dynamics and consumer expectations, with e-commerce representing a significant transformation in the fashion business. The fashion industry is the fourth largest sector in the world and is worth more than $2.4 trillion and its value is expected to continue to increase [40]. Technological development and the new digital age have led to the gradual replacement of physical stores with global virtual platforms. According to the U.S. Department of Commerce, 46% of all apparel sales were made online in 2020, representing a value of approximately $110 billion. E-commerce growth was 4% from 2018 to 2019 and 16% from 2019 to 2020. This change has increased the need to create digital products to satisfy an increasingly diverse and dynamic market, where it is also necessary to respond as quickly as possible to market demands.

Research for fashion brands' needs focuses on the development of virtual tools for promoting and offering fashion products, increasingly using virtual reality (VR) and augmented reality (AR) technologies and virtual product payments [41,42]. In addition, consumer expectations are being explored by monitoring consumer preferences and responses to the digital offering of fashion products, so that planning for future production is based on products for which there is explicit interest, which can help reduce overproduction and negative environmental impacts. Indeed, under existing business models, according to which the fashion industry is focused on mass production and stock creation, and only then on sales, only about 60% of branded collections are sold at full price, about 30% are sold at a discount, an even smaller proportion are sold in outlets, and about 10% end up in waste. Such a model requires changes both in terms of the profitability of the business and in terms of sustainability.

According to 2021 statistics, 56.8% of the world's population (4.48 billion people) use various social media platforms, which represents great potential for digital fashion marketing on social networks. Social media analysis can significantly contribute to predicting future fashion trends and guide fashion brands to develop products adapted to consumers' fashion tastes and needs. Therefore, major brands such as Zara, ASOS, H&M, Macy's, and Gap are constantly using the research results for market analysis, trend forecasting, design development, and advertising [43]. In addition, systems are being developed to analyse large amounts of data generated by searches and based on artificial intelligence, with the aim of guiding fashion companies' business plans and making quality decisions, as well as helping customers browse and search for products.

Consumer preferences are gradually changing: demand for fast fashion trends and low-quality products is decreasing, and expectations of fashion brands for high-quality, ecological clothing that can be tried on in a virtual environment before purchase are increasing. Online shopping has become an integral part of consumers' lives, especially after the Covid-19 pandemic. In this context, research is directed toward the development of digital platforms for the promotion and sale of fashion products, where customers can try on digital models of clothing and other fashion products within a digitally created retail space and virtual dressing room, which can additionally be customized to the customer's body measurements and fashion preferences [44]. By designing customized clothing on demand, designers and retailers can offer high-quality clothing based on customer preferences, significantly reducing waste and promoting improved design and manufacturing practices.

3.1VR technology for fashion

The use of CAD systems for computer design, simulation, and visualization of 3D models of garments still implies the simplest form of virtual reality, as a 3D representation of an image that can be explored by the user's interaction with a personal computer by moving the mouse or keys, in such a way that the content of the image moves in all directions and allows the user to see all dimensions of the image content. Although such a way of displaying the developed 3D models of clothing is sufficient for the analysis and evaluation of the design and the analysis of the pattern of the model in industrial conditions, visualizing the developed models only on the 2D screen of the monitor does not give the user a full

experience and perception of the developed models, and at the same time lacks an interactive multidimensional technological experience, which is becoming increasingly important for younger generations of users who are focused on digital technologies. However, the continuous development of sophisticated computer technologies leading to the overlap of the real world with the virtual world is a challenge for many fields, offering the potential for a wide application of augmented and virtual reality technologies. Augmented reality (AR) and virtual reality (VR) are the result of the increasingly widespread application and accelerated development of the capacities of information and mobile technologies. The concept of augmented reality refers to augmenting the experience of the real world by overlaying digital information in various forms to create a new experience of the observed object and space. The concept of virtual reality, on the other hand, refers to the creation of a virtual, imaginary world that can be experienced through the human senses. Advanced technologies and software solutions have enabled the development and spread of augmented reality in various fields, especially in the film and gaming industries, but also in education and other areas, where the fashion industry and digital clothing have great potential.

Fashion retailers are gradually adopting VR technology to promote virtual fashion shows for store visitors and virtual product displays. VR enhances the user experience by facilitating virtual try-on of clothes and accessories before purchase [41]. Applications available on AR range from virtual closets to digital clothing and include virtual showrooms, mobile body scanning, facial recognition, digital clothing, and interactive and digital displays. Tech service providers such as Zugara, 3DLook, Nettelo, and Atlatl offer AR -enabled apps to try out, which are already widely used in public and private retail [45].

3.2 Virtual fitting room for e-commerce

Virtual dress room is a technology that allows customers to try on clothes virtually, based on the application of augmented reality (AR) or virtual reality (VR), where the user can analyze the fit of a selected garment from a digital product collection on an image or 3D model of the body adapted to the customer's body, Figure 6. In this way, customer can assess the fit of a particular shape, color, pattern, and details of the model on a particular body, much better than in the traditional presentation of the product on the photo and the attached size chart, which in many cases do not reflect the actual dimensions of the product, leading to customer dissatisfaction, return of the ordered goods, and at the same time higher costs. Simpler virtual closet solutions for smartphones allow placing a 2D image of the clothing model on the customer's body image and adjusting the model according to the body image. More complex systems are based on the application of a 3D digital body model or avatar that is first customized to the customer's body type and measurements, and then 3D digital clothing models customized to the avatar's body can be visualized on the customized model. The ability to rotate or animate the avatar makes it possible to see the fit of the model in full, which can contribute significantly to the customer's purchase decision and immediate satisfaction [46]. Also, the development of applications for smartphones or PCs allows experimentation with different styles and clothing combinations, offering customers a new level of interactivity while reducing the need to try on real products, and production can be focused on customer needs and reduce the production of unnecessary products, which can have a significant positive impact on the environment.

More advanced solutions allow combining a tool for recommending the appropriate size with a comprehensive table of body measurements based on intelligent algorithms. The attributes and specifications of the fashion product are linked to each customer's individual buying behavior and style preferences. In addition, virtual mirrors and customizable avatars can be used in real retail centers. Here, a live customer model is used. Using an image or photos from a webcam, a customer model is created on which the customer can try on different clothing combinations from the collection and assess the fit. A device such as an HMD (eng. Head Mounted Display) can also be used, giving the user a completely new experience in which they have the impression that they are in a virtual store where they can experience a digital fashion product in a very realistic way, Figure 7.

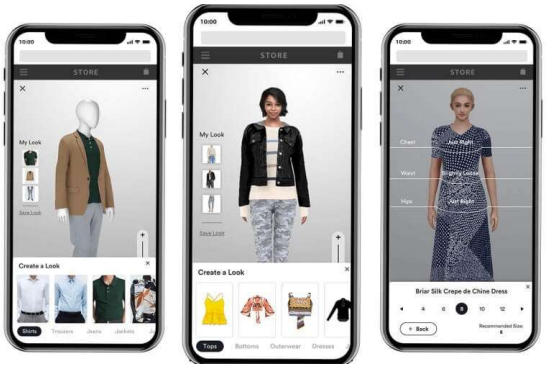


Figure 6. A virtual dress room for trying on digital clothing in e-commerce [47].

Figure 7. Application of a HMD (Head Mounted Display) device for virtual clothing try-on [47].

In addition, the application of artificial intelligence and virtual dress room enables the capture of user preferences and measurements, providing retailers with actionable insights into buying trends, sizing requirements and preferred styles. Such a system, based on big data analysis, promotes product range improvement, product customization, and supply chain efficiency.

3.3 Product life cycle management

Product Lifecycle Management (PLM) captures, tracks, manages, and shares all information about the product value chain, which encompasses the entire lifecycle [48]. Digitization has enabled great flexibility in PLM, as everyone in the PLM system can update and share information in real time with all parts of the value chain, which helps with design, planning, scheduling, and costing. Global fashion brands use this technology to ensure proper communication of product expectations, requirements, developments and progress between different departments. This highlights the ability and benefits of real-time communication during fashion product development and revision, better control over patterns and design, minimization of waste and material costs, increased efficiency, better collaboration between designers and manufacturers, integration of technical packages, and more. All of this contributes to a significant improvement in the process and proper coordination, resulting in quality work, time and cost savings, and a sustainable business.

Traditional accounting is gradually being replaced by blockchain technology as an innovative form of digital accounting, implying a database that can be used between different levels of the fashion supply chain, and users can track transactions between them [49]. The adoption of this technology increases the efficiency and sustainability of the fashion industry. Data is stored in blocks and in chronological order and is cryptographically protected so that it cannot be changed, ensuring transparency and security for all users involved in transactions.

The digitization of the entire supply chain is gradually transforming it into an integrated ecosystem that is fully transparent to all stakeholders, from the suppliers of raw materials, components and parts, to the transporters of these supplies and finished products, to the customers who expect on-time delivery of a high-quality fashion product.

4. Digital fashion in the metaverse

Globally present brands that are extending their design presence into digital worlds such as 3D animated movies, computer games, and the metaverse are gradually adopting and using services that enable the transformation of digital models of garments designed primarily for the needs of apparel production into digital models that can be used in other virtual environments and enable interaction with users on different platforms, Figure 8.

Although the concept of the metaverse dates back to 1992, when it was first mentioned in the book "Snow Crash," the term did not become popular until 2021, when social network Facebook founder Mark Zuckerberg announced a $1 billion investment in this parallel world. Facebook Inc. changed its

name to Meta, indicating the environment in which the company will invest heavily [51]. A metaverse is a virtual reality space where users can interact with computer-generated environments and other users. It combines technologies such as virtual reality, augmented reality, and holograms to create a new immersive layer where the real and virtual worlds merge. In this context, digital clothing implemented in different digital worlds of the metaverse is referred to as metafashion or phygital fashion, which means the fusion of physical and digital and refers to the marketing of clothing collections that exist both digitally and physically [52, 53].

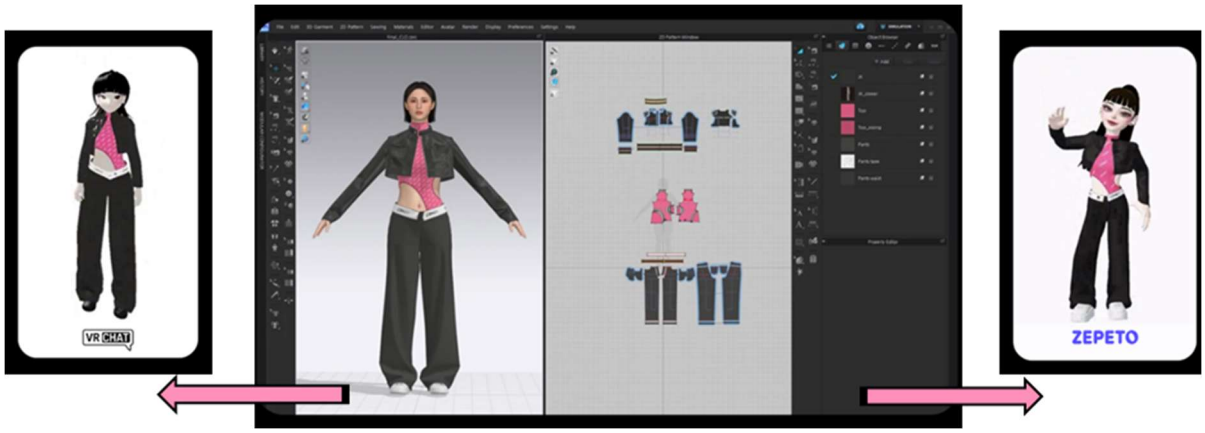


Figure 8. Creating a digital fashion product and converting it into digital models that can be used in other virtual environments and the metaverse [50].

Many global brands have recognized this format, which allows them to sell their models as both real and digital iterations of the same model, which can then be worn by the user's avatar in the virtual world. Such a model is often referred to as a 'digital twin." New generations of social networks created as different virtual worlds allow users to create their own avatars, making digital clothing an important segment through which users create their fashion identities in different environments. For the fashion brands, it opens up the possibility of new markets to which they will extend their brand in the form of digital clothing [54,55]. This also opens up opportunities for the design and creation of digital collections that are very creatively designed, as the artistic and creative potential of the designer can be fully expressed. Digital clothing and accessories can be made very complex in terms of a costume design, which is not the case with traditional real clothing.

Figure 9. Tommy Hilfiger - Metaverse Fashion Week 2022. – NFT digital fashion products [58].

Figure 10. Adidas - Metaverse Fashion Week 2023 Full Show in Decentraland [59].

Metaverse is a technology that has yet to reach its full potential, but in the last two years, more and more major fashion houses and well-known global fashion brands are already using these solutions. Creativity, innovation, creating new experiences for users and increasing customer loyalty are just some of the many benefits of this technology. Ultimately, the Metaverse has the potential to change the way brands do business and interact with customers, which can lead to new ways of creating value [56]. Fashion is among the most profitable and promising segments that already exist in the Metaverse. The most important traditional fashion weeks take place in Paris, New York, London and Milan - and from 2022 also in the Metaverse, Figure 9 and Figure 10.

The first Metaverse Fashion Week (MVFW) took place in 2022 on the browser-based platform Decentraland [57], where haute couture houses such as Dolce & Gabbana, DKNY, and Tommy Hilfiger also presented their spring 2022 collections virtually and opened a digital store where visitors could buy NFTs associated with the label [58]. NFT stands for non-fungible token and refers to cryptographically protected blockchain pieces that represent a unique digital asset that implies ownership of a specific item. They were created as a means to store value and provide easily verifiable proof of ownership for other unique forms of digital or "analog" property such as artwork, collectibles and the like. In addition to showcasing digital apparel at the event, brands and professionals also contributed to the experience with a range of virtual "skins" and other in-game items and accessories. Wearable NFTs, with their various data stored on the blockchain, can be used in both the metaverse and augmented reality, offering significant business opportunities for fashion brands [58].

Following the launch of NFT's first digital garment, the Iridescence dress on the blockchain in 2019, there has been an intense development of digital garments by an increasing number of new companies worldwide. From virtual fashion shows, Figure 11, and online retail stores, to virtual influencers and interactive fashion experiences, the opportunities the metaverse presents for the fashion industry are limitless. Fashion shows can now offer a completely different and interactive experience, with virtual catwalks in imaginary worlds and luxury virtual showrooms that allow brands and retailers to create a whole new way of communicating, promoting and selling.

Figure 11. MSTKY Studio - Meta-Fashion for Metaverse Virtual Runway Show [60].

5. Conclusion

Digital fashion technologies have been continuously evolving for many years, but in recent years the digitization of the fashion sector has accelerated significantly on a global scale due to the Covid-19 pandemic. However, the adoption and implementation of new business processes based on the digitization of all stages of the fashion supply chain is not happening at the same rate and on a global scale. Leading fashion brands that continuously pursue innovations in the field of digitalization have a significantly higher degree of implementation of digital technologies and sustainable concepts based on

them than a smaller manufacturers in the textile and fashion sector. The reasons for this are partly insufficient financial resources to invest in innovative technologies, but also the need to invest in the human resources and experts with new skills in digital product development in the fashion industry and the application of digital technologies and virtual platforms in all segments of PLM. Raising the level of digital knowledge and skills is extremely important for all stakeholders employed in the fashion and textile industry to improve business models and apply digital technologies in the development segment of fashion brands, but also in all segments of the supply chain. Innovative and interdisciplinary research and digital technologies developed for the needs of the fashion industry, increasingly based on artificial intelligence, open the possibility of extending the primary activity related to the traditional processes of production and sale of fashion products into the segment of digital product development for the needs of new generations of buyers and users of social networks and platforms and other creative industries. Harmonizing the introduction of new technologies and organizational processes in the business of fashion brands is a major challenge. However, a systematic approach to the planning, modeling and simulation of new business models and their implementation in real processes opens up the possibility for completely new developments and profitable business processes in the long term. The development of reality-based digital fashion products, augmented and virtual reality systems and technologies not only enables the creation of new value in virtual space, but also brings about numerous changes in the wider social space, in education and in the development of sustainable business models and concepts. Although there is still much space for progress, the timely recognition of the possibilities and opportunities that digital transformation can bring to fashion brands and all other stakeholders involved in the fashion industry certainly already represents a great potential for the development of future sustainable ecosystems for apparel manufacturing and distribution.

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Evaluation of the workload of workers in the technological sewing process using the OWAS method

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Abstract: The technological operation of sewing the shoulder seam was recorded during the actual process of clothing production. The OWAS method was used to determine the percentage of unfavourable working postures during the work shift, and the worker's loading angles were measured based on the structure of the technological operation. An undesirable man-machine-environment link has been discovered in the current workplace, leading to a high degree of load generated by the forced posture of the spine and head, as well as a decrease in visual abilities and movement motor skills. This research on the man-machine-environment system will serve as a basis for redesigning the workplace by establishing more favourable work postures with lower workload and fatigue that will allow for higher productivity in the workplace and higher quality of performance in technological operation.

1. Introduction

On average, the technological phase of sewing in garment manufacturing processes represents 70% of the overall time required to manufacture a garment, whereas the cutting and finishing phase is significantly less represented (approximately 30%). Studies show that during the sewing phase of a work shift, the worker spends about 450 minutes (20-30%) of their time working on technical machine-hand sewing, about 60-70% working on manual auxiliary sewing, and about 10% working on unproductive work [1-4].

Sewing is a technological technique that is an essential element of the garment production process, in which the worker sits and uses the upper body and upper limbs to handle the products and the feet to control the stitching speed of the sewing machine. This activity requires repetitive and sequential movements of the body, upper and lower limbs, and a high degree of visual acuity. This often results in a conditional forced posture of the body and head, non-physiological sitting, isometric strain on the lower limbs, and significant strain on the hands and fingers [5]. Therefore, proper posture is crucial when working in the technological process of sewing.

Fatigue arises during the execution of the work process and leads to a change in work activity, which manifests itself in a decrease in work efficiency, a change in physical condition, and a feeling of tiredness as an experience of discomfort, boredom, and need for rest. Fatigue results from a mismatch between

the physical, mental, and health capabilities of workers and the demands of the workplace, as well as a lower level of work organization and unfavorable microclimatic conditions.

In order to make the work in the technological sewing process effective, it is important to redesign or design the workplace accordingly by adapting the dimensions of the workplace to the body size of the worker and proposing appropriate work methods for each technological operation in order to reduce the psychophysical load on the worker, reduce the risk of injury and illness, and increase productivity [6-8].

2. OWAS method

The OWAS method is the most widely used workplace posture analysis method in the clothing industry. OWAS stands for "Ovaco Working Analysis System." It was developed in 1974 in the Finnish heavy industry Ovaco, where 84 different types of workplaces were identified and graphically designed [9]. The focus of the OWAS approach is on improving posture of arms, legs and back (spine). The combination of the basic postures of the different body parts determines the type of working posture when performing a particular work activity. The OWAS approach provides the following insights when analysing work postures:

- the posture of specific body parts during work,
- the involvement of individual postures in relation to the body parts,
- the part of the work process with the corresponding workplace types,
- the division of static and dynamic tasks,
- working methods and comfort of a particular posture at work and
- stresses caused by the force required in certain working postures.

According to J. Sunik [10], the OWAS technique includes 4 spinal positions (lumbar and dorsal), 4 upper arm positions, 3 hand positions, 7 leg positions, 2 body movement positions, 5 head tilt positions, and 3 mass transfer positions. The different body parts are identified with a two-digit number. The first digit indicates the physical characteristics of the body part being examined, while the second digit indicates the working posture of that body part. The individual body parts to be examined are defined by a graphic representation, a label, and a detailed description. The working postures are defined so that each body posture is entered on the recording sheet by the recorder at time intervals indicated by random visit numbers in the tables.

The workload of the worker caused by the work posture is evaluated according to the duration of each work posture according to the results of the recording, so that the percentage of a single work posture (p) is calculated in relation to the group of postures with the expression:

$$p = \frac{\sum F_p}{\sum F_s} \cdot 100 \quad [\%] \tag{1}$$

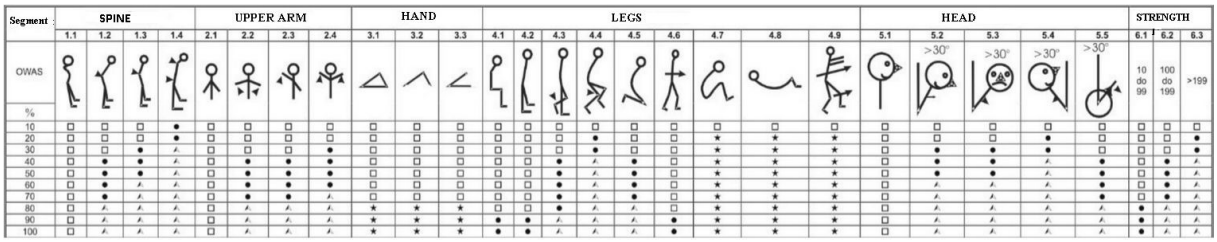
where $\sum F_p$ - number of notes of a particular posture

$\sum F_s$ - number of notes of a single group of postures

The duration of an individual's body posture (t_p) during the 450-minute working period is determined by the following expression:

$$t_p = \frac{450 \cdot p}{100} \quad [\text{min}] \tag{2}$$

Fig. 1 compares the results of the postures assessment table to determine the sequence of the workplace redesign, that is, the sequence in which the high percentage of work postures that cause worker load should be eliminated.



Legend: ☐ redesign of the workplace is unnecessary
● redesign of the workplace is necessary in the foreseeable future
⮝ redesign of the workplace will soon be necessary
* redesign of the workplace is required immediately

Figure 1. Spreadsheet of body posture assessments according to OWAS method [10]

The method is applicable in the clothing sector because the classification of basic body postures responds to the need to study working postures during the execution of technological operations. By taking into account the working postures based on the OWAS method, it is possible to design the workplace so that the employee works in a working posture that requires minimal static and dynamic load.

3. Experimental part

To record the technological process of sewing the shoulder seam, a EOS 750D camera with a built-in EFS 18-135 lens with video recording function was used. The camera was positioned so that the workplace was in the field of view as a side view, so that as many dynamic movement zones as possible could be recorded during the work process. Editing of the recordings was done on a personal computer equipped with Adobe Premier and Corel Draw software.

The technological operation was performed by a 157 cm tall worker with a lower leg length of 40 cm. The critical postures were determined using the OWAS method to estimate the workload in the workplace analysis. For 95 consecutive executions, the technological process of sewing the shoulder seam was recorded, providing 885 notes for OWAS analysis.

Regarding the structure of the technological operation, the curvature angles of the spine and head were measured by video analysis, 25 repetitions of the execution of the technological operation being analysed, i.e. 175 static images were selected, on which the angles of the spine and head were measured.

4. Results and discussion

The analysis of the worker's workload for the technological process of sewing the shoulder seam according to the OWAS method is presented in Tab. 1, together with a description of the necessary redesign of the workplace in relation to the data obtained in percentage, i.e. the duration of a particular body posture within the daily working time, and in accordance with the table for the assessment of body posture according to the OWAS method.

Table 1. Workload according to the OWAS method at the shoulder seam sewing workplace.

Workplace designation	Number of notes	Percentage [%]	Duration of the individual body posture [min]	Redesigning the workplace:
1.1	250	28.2	126.9	unnecessary
1.2	430	48.6	218.7	necessary in the foreseeable future
1.3	205	23.2	104.4	necessary in the foreseeable future
2.1	60	6.8	30.6	unnecessary
2.2	660	74.6	335.7	soon necessary
2.3	105	11.8	53.1	unnecessary
2.4	60	6.8	30.6	unnecessary
3..1	710	80.2	360.9	required immediately
3.3	175	19.8	89.1	unnecessary
4.1	855	96.6	434.7	necessary in the foreseeable future
4.2	30	3.4	15.3	unnecessary
5.1	160	18.1	81.5	unnecessary
5.2	465	52.5	236.3	necessary in the foreseeable future
5.3	260	29.4	132.3	necessary in the foreseeable future

The results obtained with the OWAS method show that the worker sits during the technological operation 96.6% of the working time (437.7 min) (position 4.1), while she works with anterior flexion of the spine at an angle greater than 15° (position 1.2) 48.6% of the working time (218.7 min), and that she works in the posture with rotation of the spine greater than 30° (position 1.3) 23.2% of the working time (104.4 min). The worker's head is bent forward at an angle of more than 30° in 52.5% of the working time (236.6 min), while it is bent to the side at an angle of more than 30° in 29.4% of the working time (132.3 min.).

When working at the sewing machine, the worker works 74.6% of the working time (335.7 min) with her upper arms facing away from her body (posture 2.2), which places a significant strain on her hands. Due to the careful positioning of the workpiece and the need to guide the workpiece while sewing, the worker puts considerable load on the fingers and hands (posture 3.1), spending 80.2% of the working time (360.9 min) in this posture.

Fig. 2 shows the working postures of the worker while performing the technical operation of sewing the shoulder seam and the corresponding kinematic chain angles. It can be seen from the photo that the worker's seat is set too high, putting a lot of load on her legs. The torso-upper leg joint system forms an angle of more than 100°. The upper leg-lower leg and lower leg-foot joint systems are within acceptable limits.

workpiece alignment | machine-hand sewing of a workpiece | cutting off the thread

Figure 2. The shoulder seam sewing workplace boundary working postures with kinematic chains.

Tab. 2 displays the different technical sub-operations for the technological operation of sewing the shoulder seam, according to which the angle of curvature of the spine and head was measured.

Table 2. Structure of technological sub-operations for the technological operation of sewing the shoulder seam.

Number of the technological sub-operation	Description of the technological sub-operation
1.	taking the front part of the T-shirt
1a	positioning
2.	taking the back part of the T-shirt
2a	putting together
2b	positioning
3.	machine-hand sewing of the shoulder seam
4.	thread cutting off
4a	laying off the T-shirt

Fig. 3 shows the average curvature angle of the spine and head, and the technological operation is broken down by sub-operation according to the diagram in Table 2. When analysing the angle of curvature of the spine and head, the technological sub-operation of laying off the workpiece was not taken into account.

When the average values of the angle of curvature of the spine were analysed, it was found that the worker works in a posture that causes the spine is strongly bent forward. When performing the technological sub-operations of positioning and machine-hand sewing, the average angle of curvature of the spine is 15°.

The worker turns the body and the head while maintaining a more upright posture of the spine to perform the technological sub-operation of taking the back part of the shirt. The average value of spine curvature during the technological sub-operations of putting together and thread cutting off is 14°, which falls within the definition of comfortable posture. The average head curvature angle shows that the worker is working at an angle of more than 30° all the time, including lateral head rotation. The head

curvature is between 37 and 43°. The calculated values match to the working postures defined by the OWAS method.

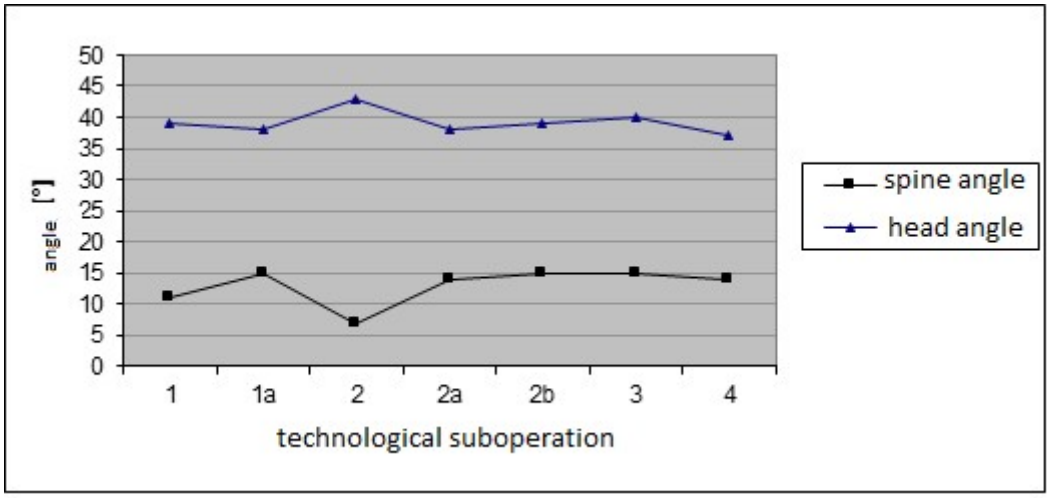
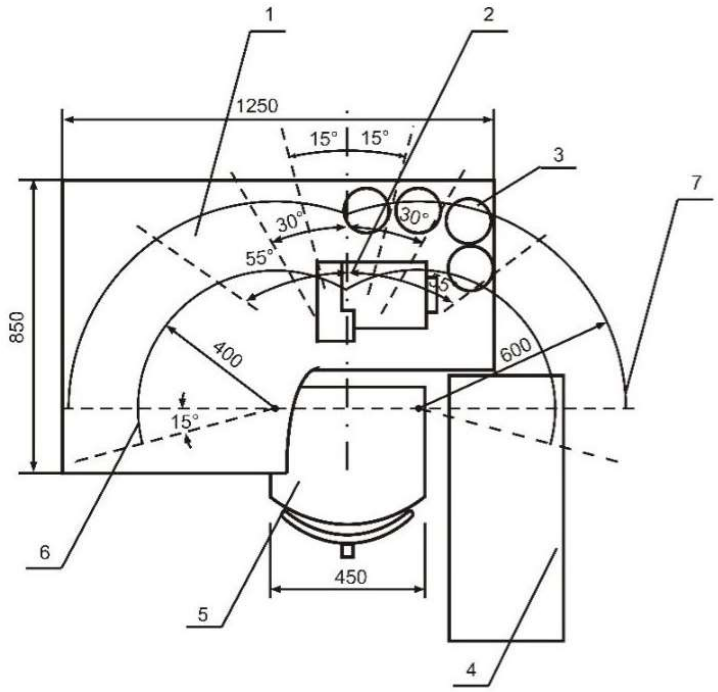


Figure 3. The curvature angles of the spine and head of a worker in the workplace of sewing the shoulder seam.

It is recommended to redesign the workplace, as the load analysis of the technological sub-operation of sewing the shoulder seam revealed a significant load on the head and spine.



Legend: 1-working surface of the sewing machine; 2-sewing machine head; 3- sewing thread stand; 4- movable stand; 5- working seat; 6- zone of normal reach; 7- zone of maximum reach

Figure 4. Designed workplace for the technological operation of sewing the shoulder seam.

Fig. 4 shows the designed workplace for the technological sub-operation of sewing the shoulder seam with reach zones and visual angles. It was proposed to redesign the workplace to increase the working area from 1050x550 mm to 1250x550(x850) mm.

It is also necessary to reduce the height of the work surface from 800 mm to 760 mm and the height of the seat from 490 mm to 460 mm in order to adapt the dimensions of the workplace to the height of the worker. It is also proposed to change the working method to reduce the workload.

5. Conclusion

Sewing is a highly technical process that requires high motor skills such as mobility and coordination of hand, arm, and leg movements. Physical and mental fatigue results from the high dynamic of movement required to complete technological operations in short time intervals. Fatigue is caused by static and dynamic fatigue of the worker's muscles, as well as by awkward working postures and the visual concentration required.

On the basis of an analysis of the technological operation of sewing the shoulder seam according to the OWAS method, it was found that the worker's stress is caused by the forward bending of the spine with an angle of more than 15° and the forward bending of the head with an angle of more than 30°. The worker sits in front of the sewing machine the entire time and works with her upper arms away from her body. Due to the required careful positioning and the necessary guidance of the workpiece, the worker places significant strain on her fingers and hand. Due to the required careful positioning and guiding of the workpiece, the worker puts significant strain on her hand and fingers. Therefore, it was suggested that the workstation be redesigned to adjust the height of the work surface and seat to the worker's height. It is also recommended that a more advantageous work approach be adopted that will significantly reduce the worker's workload and increase productivity.

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3D modelling of personalized medical devices

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Abstract. Medical devices such as supportive orthosis, used shortly after a sustained injury or bone fracture, must be tailored according to the individual measurements and characteristics of the patient. In comparison to conventional plaster and fiberglass casts, 3D technology methods (3D scanning, 3D modelling and 3D printing) allow creation of personalized medical items modelled according to the individual shape of the human body and thus meeting the necessary ergonomic characteristics. Therefore, in this work we propose the methodology for fabrication of long lasting medical devices prepared with the most appropriate selection of biodegradable building polymers such as poly lactic acid.. Firstly, the 3D scanning process of human body was performed using 3D body scanner *Vitus Smart*, which was followed by the second step of cloud preparation and 3D modelling by using Blender program. Lastly, the virtual 3D model of a medical device was exported as a g-code file. By this, the procedure for fabrication was prepared for the prototype of medical device that can be later coated and functionalized with antimicrobial agents.

1. Introduction

Bone fractures are one of the most common acute injuries. Supportive devices such as plaster and fiberglass casts are used to improve bone recuperation. These supportive devices are tested beforehand, but they unfortunately provide low ventilation, high weight, low water resistance, high occurrence of swelling and dermatitis, as well as a large waste generation after their disposal [1, 2]. Therefore, to solve these problems we propose 3D technologies (3D scanning, 3D modelling and 3D printing) which offer innovative solutions that will alleviate beforementioned shortcomings.

3D scanning has become a useful method in different branches of industry for obtaining fast and accurate product measurements [3]. Due to this characteristic, 3D scanning has been proposed as a novel method for obtaining accurate and non-invasive body measurements in apparel industry [4, 5] and especially in medical engineering. With the aid of 3D scanning, creation of bespoke implants and prosthetics, as well as better wound management and diagnostics could be achieved [6, 7]. Today, there is a wide variety of scanning technologies available, among which laser line, structured light, multi-view camera and millimetre wave technologies are most common [8].

3D modelling, otherwise known as a CAD (*Computer-aided design*) enables a precise modelling of 3D objects along the contours of digitalized scanned images, thus allowing a creation of objects with precise dimensions, while at the same time taking in account the body positions, as well as potential deformities [9, 10].

3D printing, e.g., additive manufacturing is a fabrication method in which an object is created by stacking different layers of material onto each other. The main advantage of 3D printing is the ability to fabricate tailored objects of complex geometries, while its main disadvantages are surface deformations and low production yield [11-13]. Currently, only a small number of thermoplastic polymers, photoactive polymers, ceramics and metals/metal alloys can be used as building materials [14], but with the advance of technology, innovative composites made from aforementioned materials are being researched [15]. Due to their main advantage i.e., ability to fabricate objects of complex geometries, 3D printing is useful in healthcare, with some estimates stating that by 2025. the market for 3D printing in healthcare will grow to 1,9 billion USD [11]. In recent years, a great deal of research has been conducted with the goal of fabricating medical devices for body support [16], movement aid [17] and medical training [18]. Moreover, the growing need for advanced body implants, has led to an interesting growth of research in that field. With the application of 3D printing, implants can be fabricated from biodegradable and biocompatible polymers such as poly lactic acid (PLA) [19], as well as polyglycolic acid (PGA), hyaluronic acid and polycaprolactone (PCL) [20].

Therefore, the main goal of this paper was to model an individualized, ergonomic supportive forearm orthosis using 3D scanned image, obtained using 3D body scanner *Vitus Smart*, and modelled using CAD program *Blender*. The newly designed orthosis was prepared for 3D printing, which will allow fabrication of low weight, well ventilated, water resistant and ergonomic orthosis, that is orthosis which surpasses plaster and fiberglass casts.

2. Experimental part

2.1. Methodology

For the purpose of this research, to acquire 3D scanned images, 3D body scanner *Vitus Smart* (Human Solutions GmbH, Germany) was used. 3D modelling was performed by using an open-source CAD software *Blender* (Blender Foundation, The Netherlands).

The first step in obtaining the final 3D object was scanning of the human body i.e., the left forearm, which was achieved with the use of 3D body scanner *Vitus Smart*. For the purpose of this research, a forearm of a 27-year-old male subject was scanned. The 3D scanning process lasted for approximately 12 seconds, during which the subject had to strike a pose in which the forearm was slightly angled. After the whole process, a complete model of a left forearm was obtained, as can be seen in Figure 1. To proceed with 3D modelling, point cloud preparation had to be made. Point cloud preparation is a process in which number of obtained points are reduced, while the whole 3D model is closed so as to remove any cavities which can occur during 3D scanning. This can be seen in Figure 2.

After successfully obtaining the 3D scanned image, the next step was 3D modelling of orthosis model along the obtained 3D scanned image. For this purpose, CAD software program *Blender* was used. With the aid of *Blender*, scanned image was positioned in a place and a cylindrical object with 8 vertices was placed adjacent to the scanned arm model at the height of approximately four cm (distance from the tip of the elbow to the lower edge of a cylindrical object). This is presented in Figure 3.

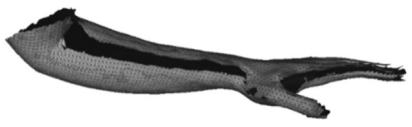

Figure 1. Initial 3D scanned model of a left forearm of a healthy 27-year-old male, obtained by 3D body scanner *Vitus Smart*. The model has numerous points, as well as a cavity along the model.

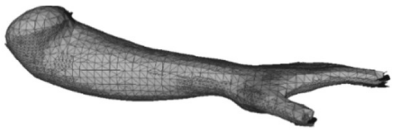

Figure 2. 3D closed point cloud of a scanned model of a left forearm.

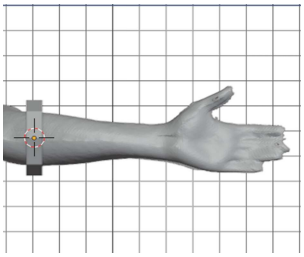

Figure 3. 3D scanned image of a forearm with a cylindrical shaped object modelled by 3D modelling program *Blender.*

Afterwards, along the length of the forearm model, a cylindrical object was extruded and adjusted to the shape of the forearm until a sleeve-like structure was obtained, with its top edge near the position of the wrist. This is showcased in Figure 4. Further on, to obtain the desired results, the upper part of the orthosis had to be carefully designed to fit the shape of the palm (a relatively flat part of the arm, which in turn is cylindrical in shape). It was decided that the orthosis would encompass 2/3 of the palm. Further on, a ring was designed to pass over the thumb and to join the two sides of the upper part of the orthosis. The closed orthosis model is presented in Figure 5.

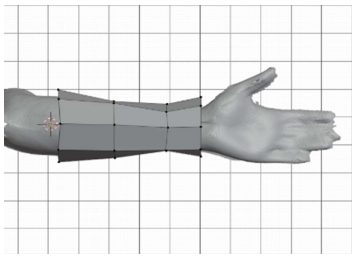

Figure 4. 3D scanned image of a forearm with a cylindrical shaped sleave modelled by 3D modelling program *Blender.*

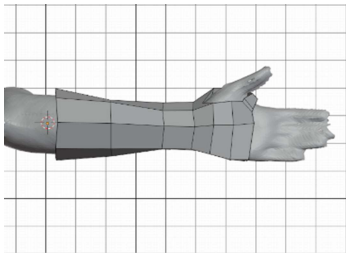

Figure 5. 3D scanned image of a forearm with a closed orthosis modelled by 3D modelling program *Blender.*

In the end, each of the planes which are clearly seen in Figure 4 were transformed. To showcase the individuality of this type of supportive orthoses, two types of orthosis were modelled, one with Voronoi pattern and one with an Elliptical pattern. Finished models of orthosis with these two types of ventilation holes are shown in Figure 6a and 6b respectively.

For research purposes, a model with Elliptical pattern was further modelled that is, orthosis was divided into two conjoined parts. This was done to advance the ease of use, as well as comfort during use.

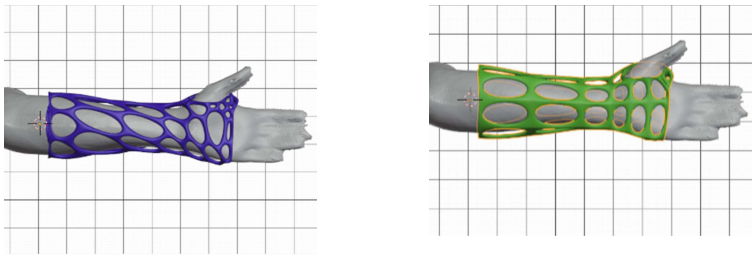

Figure 6a and 6b. Finished models of a 3D modelled orthosis with a Voronoi and Elliptical ventilation pattern.

After the final modelling was done, the 3D model of an Elliptical orthosis was prepared for 3D printing. To do this, a g-code file that contains all the necessary parameters such as infill percentage, infill pattern, extrusion temperature, and number of external layers was created.

2.2. Results and Discussion

In this research a full body scanner with which a full body scan was obtained in approximately 12 seconds was used. With the application of full body scanners, a patient's body can be scanned in a relatively short time while avoiding discomfort or unnecessary exposure to hazardous radiation.

The final model of a divided Elliptical orthosis is shown in Figure 7 and 8 respectively.

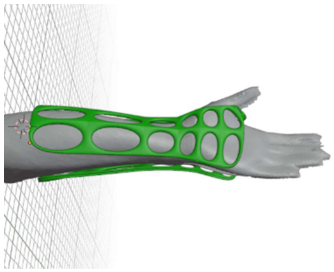

Figure 7. Divided orthosis with Elliptical pattern, parted along the edge to allow for application of medical straps.

Figure 8. Close-up of a finished orthosis model with Elliptical pattern, parted along the edge to allow for application of medical straps.

This model was designed with ease of use and comfort in mind. By dividing a full orthosis, the application of medical straps that can be tied along one of the edges of the orthosis and further tied to the other end to connect the orthosis together was enabled. By doing so, an effective and easy method of application (the orthosis can be easily placed on the patients affected arm without causing discomfort) and fixation (by using medical straps the orthosis can be easily fastened and if need arises, unfastened) has been achieved.

By preparing the 3D model for 3D printing, e.g., creating a g-code of a 3D model, print parameters were fixed and set. The final g-code model of orthosis model is shown in Figure 9. In this case, infill percentage was set at 60%, infill pattern was star-shape while the extrusion temperature was 215 °C and the number of external layers was three. The high percentage of infill, infill pattern shape and number of external layers guarantee good mechanical properties and low weight during the use, better than conventional plaster and fiberglass casts [1].

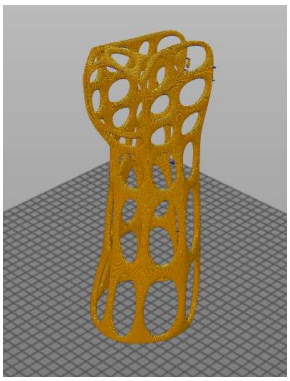

Figure 9. 3D model of forearm orthosis prepared for 3D printing, with set parameters; infill percentage, infill pattern, extrusion temperature and number of external layers.

Furthermore, it should be noted, that with the application of metal nanoparticles, such as zinc oxide or platinum nanoparticles and an advanced coating methods, such as sol-gel process, 3D printed

medical devices, in this case orthosis, can be functionalized to achieve new antimicrobial properties against highly dangerous *Escherichia Coli* and *Staphylococcus aureus* bacteria [21-23], all the while with correct application of Design of Experiment, an optimal concentration of coated antimicrobial nanoparticles can be achieved [24].

3. Conclusion

The main goal of this research, as has been already stated, was to model an individualized, ergonomic supportive forearm orthosis using 3D scanner and 3D modelling. Throughout this paper, a process which involved the aforementioned technologies was explained. With the application of 3D scanning and 3D modelling an orthosis model can easily be obtained. By using free-to use CAD programs such as *Blender*, programs that are regularly updated and can be easily learned, medical personnel can in a relatively short time model a functioning orthosis that fits along the contours of an affected body part (in this case a forearm). In conclusion, 3D printing is a versatile method which heavily rellies on other 3D technologies (3D scanning and/or 3D modelling). With the application of the aforementioned technologies, complex objects can be obtained. In this case, bespoke forearm orthosis was designed along the contours of a 3D scanned forearm. The orthoses in question were designed to fit the scanned forearm, to increase ventilation, i.e. air flow, which in turn reduces weight, and finally prepared for 3D printing with a biodegradable polymer, which allows for a safe and eco-friendly disposal. In the end with the use of 3D printing, bespoke orthosis can be functionalized with antimicrobial agents, such as metal and metal oxide nanoparticles with the application of sol-gel process, a non-destructive process which allows a formation of a durable coating. With this in mind, functionalized orthosis can aid in dealing with possible infections which can occur on skin wounds after a sustained injury [25-27]. With the use of 3D technologies, that is 3D scanning and 3D printing, decentralization of orthosis production can be obtained. A patient's arm can be scanned in a hospital, after an examination and obtained 3D images can be sent to a patient's nearest clinic, where in turn an orthosis can be fabricated and applied. By healthcare systems can be relieved of a great pressure and waiting time [28].

Acknowledgments

This research was funded by Croatian Science Foundation grant number IP-2019-04-1381 (project under title "Antimicrobial coating for biodegradable medicine materials ABBAMEDICA", project leader ass. prof. Iva Rezić PhD. PhD). Any opinions, findings and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the Croatian Science Foundation.

Ethical Approval This research was done with full consent of the participant

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Feredža as an inspiration for the design and computer development of contemporary women's clothing

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Abstract: Feredža is an oriental women's mantle similar to a cloak, made of black or blue chocha, whose primary purpose is to cover the body, head and face of a woman. Throughout history, it was primarily worn by Muslim women when leaving the house. At the same time, it is a piece of clothing, but also a social symbol of identity. The paper presents the research of the history of the feredža and its importance, as a basis for the development of contemporary women's clothing models. Given that the feredža is a garment that covers the body like a veil, the possibilities of transforming the feredža into a new design that takes on a new value, role and adapts to modern times have been explored. Using a specialized computer system, a digital reconstruction of the original model of the feredža was performed and the model was redesigned. 3D models of the original and redesigned model of the feredža were developed, in order to digitally reconstruct the original model as part of the historical heritage and national identity, and to view and analyze the new modern model in the context of a contemporary model, designed on the basis of tradition and identity symbols. In doing so, the possibilities of specialized computer programs for the digitization of clothing pattern and the computer development of realistic 3D models of clothing items were analyzed.

1. Introduction

Feredža is an expensive Oriental women's mantle similar to a cloak, made of black or blue chocha, primarily designed to cover a woman's body and head. Throughout the Ottoman history of Bosnia, it was worn by prominent women when leaving their homes, Figure 1 [1]. The feredža is a type of wide coat with wide sleeves and a large collar around the neck. It was typically accompanied by a veil made of white muslin to cover the lower part of the face and a white scarf to wrap around the head and forehead, Figure 2. The collar size indicated class and social differences. The wealthiest women had collars that matched the length of the feredža, adorned with gold embroidery, Figure 3. It represented a symbol of status, prestige, and not every woman had a feredža [2]. The feredža is a symbol of Ottoman Bosnia, but it is important to note the difference between urban and rural women of that time. Urban women in such a traditional and patriarchal society fully embraced the custom of covering their faces, so when going out in public, they would wear a feredža or zar. Both Christian and Jewish women in cities wore feredža and zar because prevailing moral norms considered it highly improper for women to

move around uncovered in urban areas [3]. The situation was quite different in rural areas, where women participated in economic production alongside men. Rural women freely moved around their villages and rarely concealed their faces from strangers. With the Austro-Hungarian occupation of Bosnia and Herzegovina in 1878, the first phase of women's emancipation began, which also focused on their unveiling or covering. The hardships of war and threatened livelihoods compelled women to search for employment, which created space for removing the ferdža and zar. After the end of World War I in 1918 and Bosnia and Herzegovina's entry into the new Yugoslav state, discussions intensified regarding women's issues in general, focusing on the unveiling of women's faces, which was linked to illiteracy and the general backwardness of the entire Muslim community [4]. In light of these discussions, World War II arrived, drastically changing women's attire. As Muslim women took part in the anti-fascist struggle, their literacy and social engagement increased, accompanied by the unveiling of their faces. On September 29, 1950, the National Assembly of the People's Republic of Bosnia and Herzegovina passed a law banning the wearing of zar and feredža, thus consigning this garment to history [5]. The status and value of the feredža are best illustrated by the fact that it was not uncommon for one feredža to be borrowed and used by all women in one household [6] or even by neighbors. Along with the feredža, two types of headscarves were worn, jašmak and čember [1]. Jašmak covered the lower part of the face up to the eyes, while čember was tied over the head and jašmak. Both jašmak and čember were worn in white.

Figure 1. Feredža from the Ottoman period located in the Zavičajni Muzej in Visoko, Bosnia and Herzegovina [6].

Figure 2. The way the feredža was worn with a veil made of white muslin to cover the lower part of the face and a white scarf to wrap around the head and forehead [1].

Figure 3. Feredžas from the late 19th and early 20th centuries [1].

For the research presented in this paper, the feredža was specifically chosen as inspiration and a starting point for the redesign of this historical garment, as well as for exploring the possibilities of digital 3D reconstruction of both the historical and the contemporary redesigned model. The need to redesign a particular garment from history is a way to reflect upon it, draw new conclusions, and provide critique. The feredža is a universal symbol of a specific era, which can easily be accepted in our time if approached from a fashion standpoint. Redesigning does not necessarily mean changing; it is a transformation through time and technology that results in a completely modern understanding, perception, and reintegration into the world of fashion. The feredža, as a garment, is highly inspiring because it conceals the inner and becomes external, a covering and protective layer of clothing, the visible aspect that we want others to see. In a way, it becomes a costume, assigning a role and status to the woman wearing it.

2. Application of 2D/3D CAD systems for the reconstruction of historical clothing

The development of technology and systems for virtual environments and virtual reality has led to the emergence of virtual museums that enable interested individuals to take virtual walks and explore exhibition displays online, making historical content accessible to a wide audience [7,8]. A significant part of cultural heritage and history is preserved through various textile and clothing items. In this regard, 2D/3D CAD systems for clothing simulation, which allow the development of computer prototypes of clothing models, find their application in the digitization of museum historical clothing [9-12]. During the process of developing a computer-generated 3D prototype, 2D patterns are created, and the properties and appearance of textile materials and accessories contained in the garment are defined. In this way, the complete construction preparation and technical documentation of each item remain digitized and permanently stored. Rare museum specimens can be preserved through this method, which are otherwise accessible to only a small number of interested individuals or not accessible to the public at all due to their sensitivity. Digital or even physical replicas, created based on digitized documentation, can be used for viewing as well as educational purposes, providing future generations with a better understanding of history and the social conditions of a particular era [13-15].

3. Computer 3D reconstruction of the historical feredža model and contemporary redesign

3.1. Construction and 3D simulation of the historical feredža model

Based on the sample of the historical feredža model located in the Zavičajni Museum in Visoko, sketches and technical drawings of the model were made as shown in Figure 4, and the 2D pattern pieces were reconstructed using CAD system, as shown in the Results, Figure 7. The possibilities of complex computer 3D reconstruction of the historical feredža model were explored, considering all the necessary parameters of pattern pieces and joining segments for model simulation. When setting the parameters of the pattern pieces, special attention was given to the positioning of the pattern pieces around the body model, considering that it is a voluminous garment where material gathering and folding occurs in a larger number of joining segments. Variations in the polygon mesh size that defines the surface of individual pattern pieces were explored. This determines the possibility of spatial deformation and ensures proper gathering and folding in the pattern segments. The density of the polygon mesh must also be correlated with the parameters of the physical and mechanical properties of the materials used for simulation. Since it is a multi-layered garment, it is necessary to properly define the layers of material for the pattern pieces to avoid surface penetration during simulation. On the cloak pattern piece, the possibilities of defining material folds at precisely determined positions and under specific angles were explored to achieve proper formation of the hood during simulation of head covering, as shown in Figure 5. The sleeve cuffs and the length of the model were constructed as separate pattern pieces to allow the application of embroidered ribbon texture in the final stage.

Figure 4. Sketch and technical drawings of the historical feredža model.

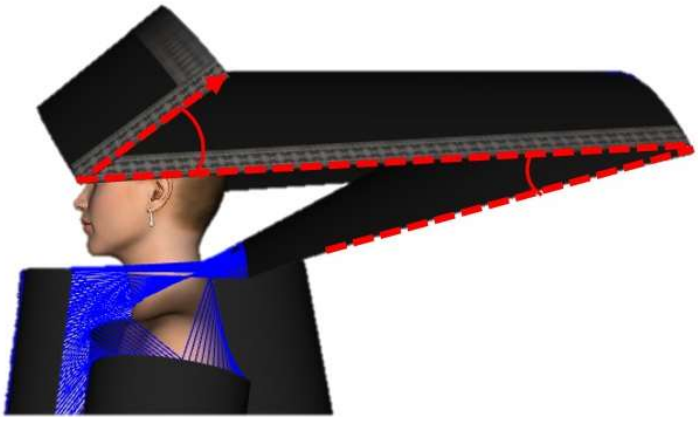

Figure 5. Positioning and folding of cape cutting part.

Considering the impossibility of determining the properties of the original fabric due to it being a unique museum artifact, it is necessary to carefully select and apply a material for simulation that closely matches the original in terms of its characteristics, such as a smooth drape, good bending and shearing properties, low stretching, and a slightly thicker and heavier texture, as it is a chocha fabric. In this regard, simulations were conducted with different applied materials, and the parameters of material properties that ensure the desired visualization and appearance of the simulated feredža model were explored and determined, as shown in Table 1, material A. After performing the 3D simulation, colors and textures of textile material and corresponding embroidered ribbons were applied to the model, thus fully developing and reconstructing the 3D prototype of the historical feredža model.

Table 1. Characteristics of textile materials for simulation of historical feredža and redesigned dress.

		Parameters of physical and mechanical properties						
		Tensile properties		Bending properties		Shear property	Compression property	Weight
Material composition	Structure	EMT – x[a] [%]	EMT – y[b] [%]	B – x[c] [cN*cm]	B – y[d] [cN*cm]	G[e] [cN/cm]	T0[f] [cm]	W [g/m^2]
A - 65% PES 35% viscose fiber	canvas	3,97	6,27	0,34	0,22	1,15	2,42	367,00
B - 100% cotton	knit	11,82	27,64	0,027	0,032	2,28	0,60	126,00

[a]Tensile elongation in the warp direction at a force of 490 cN/cm
[b]Tensile elongation in the weft direction at a force of 490 cN/cm
[c]Flexural stiffness in the warp direction
[d] Bending stiffness in the weft direction
[e] Shear stiffness
[f] Fabric thickness

3.2. Redesign of the historical feredža model

The historical feredža model served as an inspiration for the contemporary redesign of the dress shown in Figure 6.

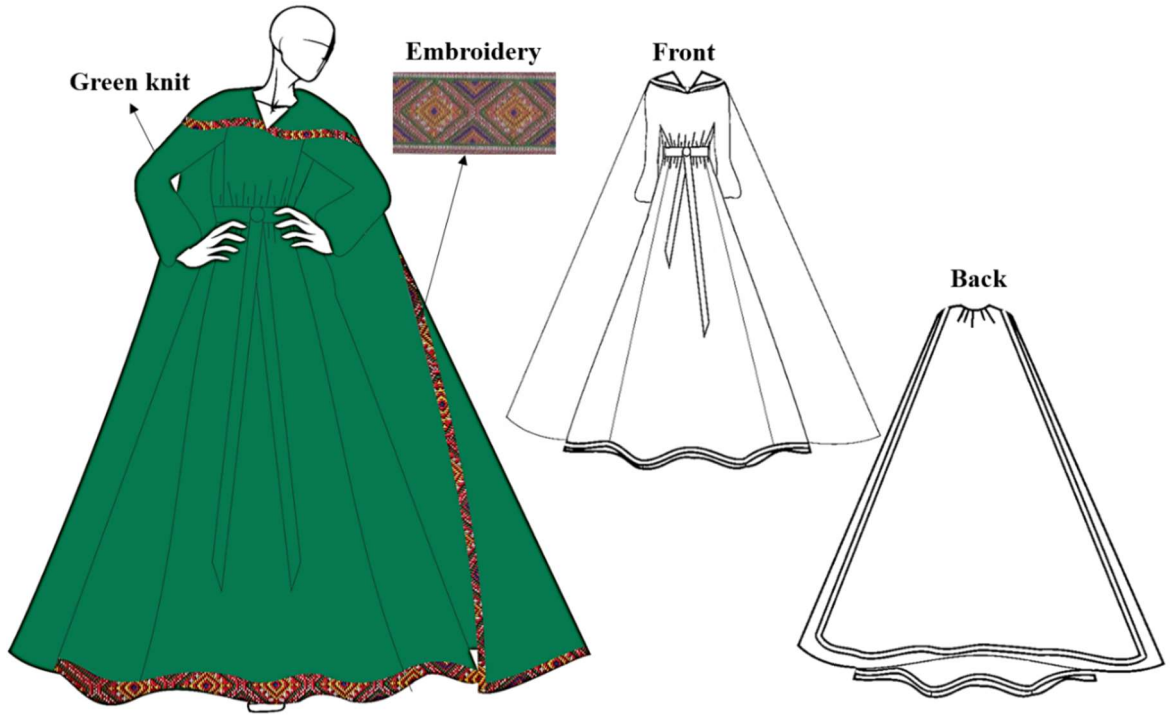

Figure 6. Sketch and technical drawings of redesigned dress based on the feredža.

The basic bell-shaped form of the feredža was retained, the front center fastening was removed, and a waist belt was added. The previously developed digital pattern of the historical model was used for modelling the pattern according to the dress sketch. Based on the explored possibilities and defined

parameters for the development of a historical feredža 3D prototype, all the necessary parameters for the 3D simulation of the redesigned dress were set, with the properties of knitted material, Table 1, material B, applied to the pattern pieces, which correspond to the material intended for the production of the physical prototype of the model. Colors and textures of the material and embroidered trims were applied to the developed computer-generated 3D prototype, as shown in the Results, Figure 10. The entire process of redesign and computer development of the 3D dress model was verified by creating a physical prototype.

4. Results

4.1. Results of digital 2D patterns development for the historical feredža and the redesigned dress

Figures 7 and 8 present digitally developed 2D pattern pieces of the historical feredža model and the dress inspired by the historical feredža model, with highlighted positions of the sewn embroidered trim.

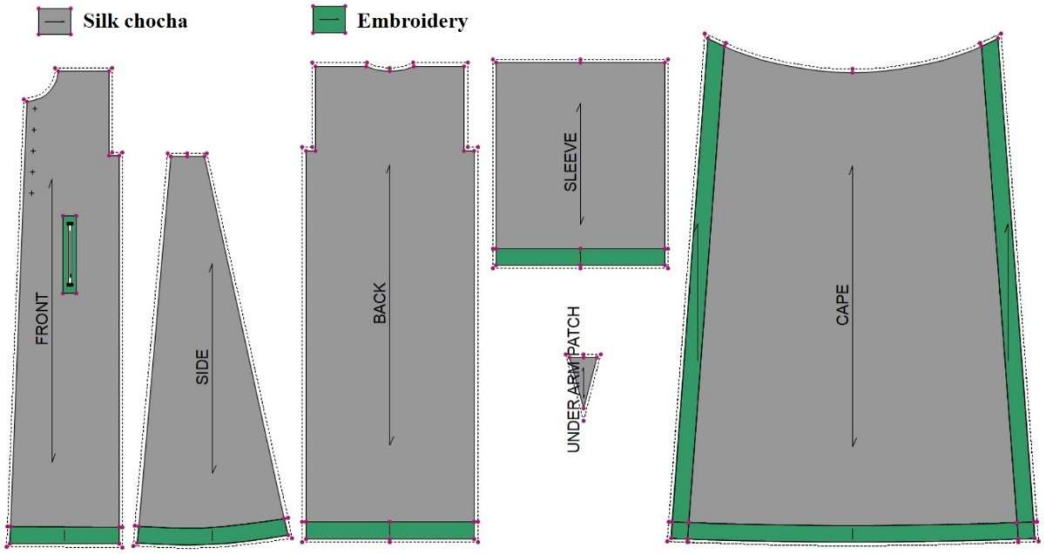

Figure 7. Cutting pattern of the historical feredža model.

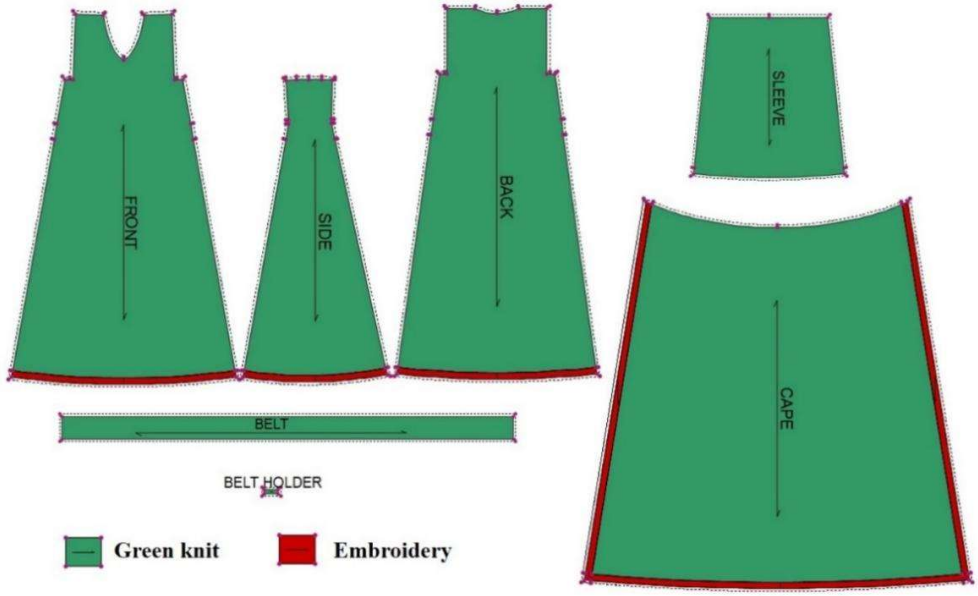

Figure 8. Cutting pattern of the dress model inspired by the feredža.

4.2. Results of the 3D prototypes development of the historical feredža and the redesigned dress
The following figures presents digital 3D prototypes of the historical feredža model, shown in Figure 9, and the designed dress model inspired by feredža with a created real prototype, shown in Figure 10.

Figure 9. 3D prototype of historical feredža model.

Figure 10. 3D prototype of the dress inspired by the historical feredža.

By systematically analysing the values of each parameter and conducting multiple 3D simulations, the desired form of the historical feredža model was achieved based on the selected museum template. During the development process of the digital 3D model of feredža, particular attention was given to the issue of material layer penetration, considering the volume and folds in specific segments. Optimal parameter values for the layers of pattern pieces, polygon mesh density, and the physical and mechanical properties of the textile material were determined for the simulation, ensuring the visualization of the 3D model without unwanted penetrations. Precise positions and angles of the folds on the cape pattern piece were established for the simulation of the head covering formation, preventing the falling and pulling back of the entire pattern piece under the influence of material weight. By applying color and texture to the material and incorporating digitized and formatted photographs of the embroidered trims found on real models, a realistic appearance was achieved, corresponding to the real models of the historical feredža and the redesigned dress model.

5. Conclusion

The capabilities of 2D/3D CAD systems used today for computer-aided design and development of new clothing models allow high-quality digitization and pattern development, as well as 3D reconstruction of historical garment models. Given the complexity of historical garments' forms, optimizing and defining parameters for conducting 3D simulations pose a challenge that requires an interdisciplinary, creative-engineering approach to achieve accurate form and realistic 3D visualization of such models. By reconstructing the 2D pattern pieces and exploring simulation parameters, an appropriate visualization of the historical feredža model in a digital 3D format has been achieved, which can be used for teaching, enriching museum collections, or creating online content. The model, together with all its technical characteristics, has been fully digitized and permanently stored.

Redesigning the historical feredža model into a contemporary dress presents a significant design challenge that allows for the revival of a garment that has belonged to history for seven decades. The redesigned feredža provides us with a new perspective on the universality of this intentionally withheld historical garment. The application of CAD systems for developing computer-generated models of fashion garments based on digitized patterns of historical models opens up a wide range of possibilities and limitless design inspiration. It also enables the preservation and transmission of traditional cultural elements of garments into the modern era.

Acknowledgment

The authors would like to express their gratitude to Mr. Muamer Kolar, a professional photographer, and Aida Mahmutović, as the model, for their assistance and commitment in the photo shoot of the redesigned feredža model.

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Semantic adaptation of German expressions in a fashion and design context

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Abstract. Semantic adaptation refers to adapting the meaning of a foreign word to the language system of the recipient. When a word is "borrowed" from a foreign language, its original meaning may be lost or changed to better adapt to the new linguistic environment. This usually happens in the process of long-term use of the word in the target language, during which a new connotation of the word may gradually develop. In this research, the semantic adaptation of words of German origin into the Bosnian language system refers to the adaptation of the meaning of words that have been integrated into the Bosnian language. We study how words of German origin, expressions related to the field of clothing in a fashion context, are adapted to the Bosnian language system and what changes in their semantics were observed after integration into the Bosnian language. This paper will also analyze the representation of German words in the field of clothing and fashion and investigate how often they are used in the Bosnian language. By combining the analysis of the semantic adaptation of words and the research on the frequency of word usage in the Bosnian language, the paper will provide insight into the influence of the German language on the Bosnian language in fashion terminology.

1. Introduction

With the aim of analyzing frequent Germanisms in the Bosnian language, a corpus of over a thousand words identified as Germanisms was collected. The corpus was formed as part of the research work *Morphological adaptation of frequent Germanisms in the media and their representation in dictionaries of the Bosnian language* [2], where Germanisms were excerpted from the most widely read newspapers in the Bosnian-speaking area in Bosanska Krajina (which is in the northwestern part of Bosnia and Herzegovina): *Dnevni avaz*, *Krajina*, *Moja Sana* and *Reprezent* [19-22].

In this paper, special attention will be devoted to the analysis of the semantic adaptation of Germanisms in the conceptual field: clothing and fashion.

The theoretical basis of this work is primarily Rudolf Filipović's study - *Languages in contact* [6], his terminology, and the model of linguistic borrowing that most Germanists refer to.

On language borrowing, Filipović, relying on Uriel Weinreich's opinion, points out three basic elements from which every language borrowing starts: the place of contact, the bilingual person, and the consequences of using more than one language. Filipović describes *languages in contact* as those that are used alternately by the same speaker. That person is called bilingual, and the phenomenon when one

speaker uses more than one language is called bilingualism. When one speaker uses several languages, interference occurs, which is a consequence of this phenomenon.

The element (word) X as pronounced by speakers of the donor language is called a model, and the borrowed element as pronounced by speakers of the recipient language is called a replica. The two languages that participate in this process are called the donor language and the recipient language.

When two language systems come into contact, words from one language are transferred to the other. When taking lexemes from one language to another, in this case from German to Bosnian, certain changes occur at different levels. This paper focuses on the semantic adaptation of Germanisms from the field: clothing and fashion.

2. Taking over and adapting foreign words into another language system

When taking foreign words into another language, a process of adjustment or adaptation occurs. This process is necessary considering that words often have such a phonological, orthographic, or morphological form that does not correspond to the recipient's language system.

The word is changed as much as necessary to better fit into the new system. According to R. Filipović, the levels at which changes may or may not occur are phonological, morphological, semantic, and lexical [6].

Adaptation is a long-term process, and until its final form, it undergoes primary and secondary changes, according to which primary and secondary adaptation are distinguished.

The task of the analysis of adaptation processes is to describe the changes the foreign word went through in the primary phase, i.e., from the moment of borrowing to the formation of the basic or final form - which in contact linguistics is called a replica - and what changes occur in the replica in the secondary phase, i.e., from the moment of integration into the recipient language system onwards.

Different language levels require a different approach to the problem. All theorists of contact linguistics agree that a loanword necessarily first goes through the process of forming a phonological form. Namely, the phonological systems of the two languages never completely match, so the phonological elements of the donor language are replaced by native ones that are most like them in terms of articulatory-acoustic properties, and the problem of phonological mismatch is solved by omitting or inserting native phonological elements.

Phonological adaptation is always followed by morphological adaptation. Every foreign word, now of transition to a new language system, brings with it the morphological characteristics of the type of word it belongs to. As the morphological systems are different, the loanword must harmonize and adapt its morphological features to the rules of the recipient language. There may or may not be a reshaping of the basic form of the loanword.

Adaptation specifically at the semantic level refers to the adjustment of the meaning of a foreign word in the new language system. This is usually achieved by taking on new meanings from the context in which the foreign word is used in the recipient language. In some cases, a new meaning can also be formed for a foreign word, which can lead to different meanings in both donor and recipient languages.

Shortly, the adaptation of foreign words into another language system is a complex process that includes adaptation at the phonological, morphological, lexical, and semantic levels. This adaptation can be primary or secondary and depends on the context and linguistic needs of the recipient. Therefore, the adaptation and integration of foreign words requires careful observation of the context and linguistic needs of the recipient.

3. Processing of the analysis of the adaptation process of Germanisms at the semantic level

In this research, special attention is paid to the analysis of the process of semantic adaptation of Germanisms into the Bosnian language, both in the primary and in the secondary phase.

It is important to emphasize that the semantic adaptation of Germanisms refers to the process of adapting the meaning of a foreign German word in a new linguistic context. This process is not mechanical but requires creative reshaping of words to fit them as well as possible into the new language

system. As such, this process is interesting for several reasons, as the study of semantic adaptation can provide insight into the way people perceive and adapt to new cultures and languages.

Therefore, the processing of the analysis of adaptation of Germanisms will show how certain German words were adapted to the Bosnian language system and what are the specifics of the process of semantic adaptation of Germanisms in this context.

For this purpose, Germanisms that are frequent in the field of clothing and fashion have been singled out from the corpus. These are, for example: *ancug, bademantil, baletanke, blajh, blajhanje, blajhati, brile, bushalter, ceker, cof, cvikere, faltna, farba, farbati, feler, fen, feniranje, filc, fleka, flekica, futer, futrola, heklanje, hekleraj, hozntregeri, jakna, knap, kragna, kragnica, lokne, loknice, mašna, mašnica, mider, nitna, nitnica, ofinger, pakung, perla, pertle, rajf, rajsferšlus, ranac, ring, ruksak, samet, šlafrek, šlajer, šlafe, šlafice, šlepa, šlic, šminka, šminkati, šminker, šminkerica, šnala, šnalica, špic, špigla, štih, štikle, štiklice, štirka, štirkano, štof, štrample, štramplice, štrik, štucna, tašna, tufna, tufne, vikler, vindjaka.*

As was emphasized at the beginning of the paper, the methodology of Rudolf Filipović is used in the processing, who in his analysis of semantic changes accepted Hope's division system and then modified it. In his methodology, Filipović emphasizes the need to separate adaptation processes into two phases and states that by applying primary and secondary adaptation at the semantic level, a new division is obtained that meets the needs of analysis of semantic changes, i.e., changes of meaning in loanwords. [6][1]

As on other levels, Filipović uses a three-part classification.

Based on the comparison of the meaning of the model with the meaning of the replica, Filipović classifies the changes into three categories: zero semantic extension, narrowing of the meaning and expansion of the meaning. This division is based on the distinction between primary and secondary adaptation.

Primary adaptation includes: zero semantic extension (no difference in meaning between model and replica), narrowing of meaning in number (change from multiple meanings to one meaning) and narrowing of meaning in the meaning field (change from general meaning to special meaning).

Secondary adaptation includes the expansion of the number of meanings and the expansion of the field of meanings. In secondary adaptation, there are also changes related to metaphor, metonymy, pejoration, and ellipsis [18].

3.1. Zero semantic extension

When a German loanword (replica) enters the Bosnian language system and retains an unchanged meaning that fully corresponds to the original German model, it is called *zero semantic extension*. Filipović also calls such changes of meaning a *transfer of meaning*. This especially applies to terms whose meanings are precisely defined, such as professional names from various fields such as the fields of fashion, sports, gastronomy, technology, construction, agriculture and others, and names of members of various movements, studies and trends or nouns that they denote the bearer of some characteristic or composition. When taking these objects and their expressions, their meaning is just transferred or retained as it was.

Analyzing Germanisms from the corpus of selected terms from the field of *clothing and fashion*, in most cases, it is about models that have one or fewer meanings, and only the specific meaning is conveyed. It rarely happens that more than one meaning of a word is transferred into the recipient language. Therefore, the zero semantic extension can be divided into two groups:

[1] "Primjenom primarne i sekundarne adaptacije na semantičkoj razini dobili smo novu podjelu koja zadovoljava potrebe naše analize semantičkih promjena odnosno promjena značenja kod posuđenica" [6]

The first group consists of models with one taken meaning, such as: *anzug* < *Anzug* [2] (suit), *bademantil* > *Bademantel* (bathrobe), *baletanke* > *Balletschuhe* (ballet shoes), *blajhati* > *bleichen* (tinting or lightening hair color), *brile* > *Brille* (glasses), *bushalter* > *Brusthalter* (bra), *ceker* > *Zöger* (bag made of material for carrying groceries, shopping, as an alternative to plastic bags), *faltna* > *Falte* (wrinkle, e.g. on clothes), *farba* > *Farbe* (color), *feler* < *Fehler* (error), *fen* > *Fön* (electric hair dryer), *filc* > *Filz* (woven wool cloth, used, for example, to make hats, etc.), *futer* > *Futter* (thin cloth that is sewn inside clothing; lining), *futrola* < *Futteral* (covers, boxes for carrying or holding objects, instruments, etc.), *heklanje* > *häkeln* (handwork performed with the help of a specific needle with a hook), *hozntregeri* > *Hostenträger* (straps that hold the trousers), *jakna* > *Jacke* (garment to protect against wind and rain), *knap kragna* > *Kragen* (part of the shirt around the neck), *lokna* > *Locke* (curly or wavy texture of hair), *mider* > *Mieder* (a piece of clothing used to tighten the waist for aesthetic or therapeutic reasons), *nitna* > *Niete* (a metal fastener that firmly joins parts), *ofinger* > *Aufhänger* (a clothes hanger or holder), *perla* > *Perle* (an ornamental ball whose shape resembles a pearl and which is worn in a necklace or other clothing decoration), *pertla* > *Bertl* (lace, cord), *rajf* > *Reif* (accessory or hair ornament, in the form of a tight part that prevents the hair from eye-catching), *rajsferšlus* > *Reißverschluss* (zipper on clothes or similar), *ranac* > *Ranzen* (sports bag), *ring* > *Ring* (ring), *ruksak* > *Rucksack* (backpack), *samet* > *Samt* (a type of fabric that is smooth, thick and soft), *šlafrek* < *Schlafrock* (cloak), *šlajer* > *Schleier* (an accessory on a wedding dress or formal dress, which is transparent and is worn over the head or attached to a hairstyle), *šlafe* > *Schlapfen* (a type of footwear or thick socks worn as house clothes), *šlepa* > *Schleppe* (extended, back-falling part of a dress or wedding dress), *šlic* > *Schlitz* (a cut or opening on garments), *šminka* > *Schminke* (make-up), *šnala* > *Schnalle* (hair clip), *špigla* > *Spiegel* (mirror), *štikle* > *Stöckelschuhe* (high heels), *štih* < *Stich* (charm, elegance), *štirka* > *Stärke* (stiffener), *štrample* > *Strampel* (socks that extend over the legs, tights), *štrik* > *Strick* (rope), *štucna* > *Stutzer* (stiff socks or some device that protects the leg from the ankle to the knee, not feet), *tašna* > *Tasche* (bag), tufna >Tupfen (dot, round spot or pattern on fabric), *vikler* > *Wickler* (curler for shaping hair, creating curls, waves or volume in hair), vindjaka > Windjacke (windbreaker).

It should be especially emphasized that the models of our corpus, which belong to the first group, are often compounds composed of two words taken as a whole. These are, for example, the following words: *ancug* > *Anzug, bademantil* > *Bademantel, bushalter* > *Brusthalter, futrola* < *Futteral, hozntreger* > *Hozenträger, ofinger* > *Aufhänger, rajsfer*šlus >*Reißverschluss, ruksak* > *Rucksack,* šlafrek > *Schlafrock, vindjaka* > *Windjacke*. The compound models in our corpus belong to the determinative compound type, where each word within the compound has its own meaning and function in the formation of the compound. The second part of the compound determines the morphosyntax and semantics of the whole word, while the first part modifies the semantics of the second part of the compound.

It is noted that during the transfer of German compounds into the Bosnian language, this structural feature was not recognized, so the compounds were transferred as a whole and functioned as a basic form and were fully adapted to the phonetic and morphological level of the Bosnian language. For this reason, they are not separated from this first group.

The second group consists of models with two or more derived meanings, such as:
cof > *Zopf*

[2] Translations of German words into Bosnian and then into English are author's, and the dictionaries used during the translation into Bosnian are: *Rječnik bosanskog jezika* by Ibrahim Čedić and collaborators [1] *Rječnik bosanskog jezika* by the group of authors Senahid Halilović, Ibrahim Palić and Amela Šehović [16], and the Great Dictionary of Foreign Languages the words of Klaić Bratoljub [16].
Prijevodi njemačkih riječi u bosanski jezik a zatim engleski jezik su autorični, a rječnici koji su korišteni prilikom prevođenja na bosanski jezik su: *Rječnik bosanskog jezika* Ibrahima Čedića i saradnika, *Rječnik bosanskog jezika* grupe autora Senahida Halilovića, Ibrahima Palića i Amele Šehović te *Rječnici bosanskog jezika* Dževad Jahića [7-15].

Two meanings have been taken over into the Bosnian language: 1. a part of the hair that rises on the head as a hairstyle 2. bait for fishing
Meanings from Duden[3]: 1. Hair hanging down braided from several strands. 2. Bread or similar in the form of a pigtail 3. slight frenzy 4. thinner end of a tree trunk 5. fishing line braided from several thin fibers.[4]
flek < Fleck
Two meanings have been taken over into the Bosnian language: 1. in general, something that is impure, dirty 2. specific meaning in medicine, a shadow or spot that can be recognized on some part of the body, for example, a shadow on the lungs.
Meanings from Duden: 1. soiled area 2. area of different color 3. specific area or point 4. patch 5. grade "insufficient"[5]
knap < knapp
Two meanings have been taken over into the Bosnian language: 1. only as much as is sufficient; barely 2. tight, tight (e.g., pants)
Meaning from Duden: 1. only present in very small quantities 2. just made up 3. somewhat less, not quite hardly 4. very close 5. tight, tight-fitting 6. gathered, reduced to the essentials 7. short, small, minimal [6]
mašna < Masche
Two meanings have been taken over into the Bosnian language: 1. a decorative ribbon tied in a knot with the ends falling freely 2. a decorative part of clothing; a silk or similar band tied around the shirt collar; bow tie
Meanings from Duden: 1. Loop made of yarn, wire or similar, which is created when crocheting or linking 2. Loop 3. Trick, clever procedure [7]
pakung < Packung
Two meanings have been taken over into the Bosnian language: 1. packaging; pack 2. in cosmetics, a treatment for hair and scalp care
Meanings from Duden: 1. Wrapping, wrapping, box with goods 2. Wrapping (of body parts) with towels to allow moisture, heat or cold to have a healing or cosmetic effect on the body 3. High defeat; Beatings, beatings 4. Equipment 5. Stone layer as a base, base [8]
špic < Spitze
Of the eight, four meanings are taken over: 1. top 2. the peak of the season or the like, 3. in sports "peak" means a player in different positions in different sports and 4. material made of threads in different techniques with artistically made patterns; lace.

[3] The dictionary that was used when comparing meanings and downloading data about the meaning of words in the original German language is the *Duden Onlineworterbuch and Duden Herkunftsworterbuch* [4-5].

[4] Meanings originally taken from dictionary are: 1. aus meheren Strängen geflochtenes herabhängendes Haar. 2. Brot o Ä. in der Form eines Zopfes 3. leichter Rausch 4. dünneres Ende eines Baumstammes 5. Angelschnur, gflochten aus meheren dünnen Fasern.

[5] Meanings originally taken from dictionary are: 1. verschmutzte Stelle 2. andersfarbige Stelle 3. bestimmte Stelle oder Punkt 4. Flicken 5. Schulnote "ungenügend".

[6] Meanings originally taken from dictionary are: 1. in nur sehr geringer Menge vorhanden 2. gerade aufreichnung 3. etwas weniger; nicht ganz kaum 4. sehr nahe 5. (von Kleidung) eng, fest anliegend 6. gerafft, auf das Wesentliche beschränk 7. kurz, klein, minimal

[7] Meanings originally taken from dictionary are: 1. Schlinge aus Garn, Draht o.Ä., die beim Häkeln oder Verknüpfen entstehen 2. Schleife 3. Trick, schlaue Vorgehensweise

[8] Meanings originally taken from dictionary are: 1. Hülle, Umhüllung, Schachtel mit Ware 2. Umhüllung (von Körperteilen) mit Tüchern, um Feuchtigkeit, Hitze oder Kälte heilend oder kosmetisch auf den Körper einwirken zu lassen 3. hohe Niederlage; Schläge, Prügel 4. Ausrüstung 5. Steinschicht als Grund, Unterlage

Meanings from Duden: 1. sharp, sharp end of something 2. beginning of e.g., season 3. forward playing in front position 4. topflight 5. maximum value, peak 6. amount remaining in set-off 7. malicious remark directed at someone 8. Material made from threads in different techniques with artful openwork patterns[9]
štof < Stoff
Two meanings are taken over: 1. type of solid fabric 2. data for conversation or discussion, presentation or similar.
Meanings from Duden: 1. woven, knitted product of yarn, specially processed for clothing 2. substance 3. alcohol or narcotic 4. something that provides a basis for artistic design, scientific representation, treatment; something for someone to talk about. [10]

3.2. Meaning narrowing.
Narrowing of meaning is the most common phenomenon in the process of semantic adaptation of foreign words into the Bosnian language. The analysis of Germanisms in the Bosnian language revealed that German words have multiple meanings, but in the process of semantic adaptation into the Bosnian language, only one meaning is usually retained, which is necessary for naming a specific concept or object. This represents the specialization of many meanings of the model to one specific meaning, which we call meaning narrowing.

Meaning narrowing can refer to the narrowing of the number of meanings, which is a very common occurrence. Some Germanisms in the Bosnian language also show a narrowing in the field of meaning, which is a double narrowing: in the number of meanings and in the assumed field of meaning.

This research paper confirms the tendency of narrowing the model in the number of meanings and conveying one specific meaning of the model. For example:

The corpus of this research confirms that the narrowing of meaning in the field of meaning occurs very rarely and it is difficult to precisely determine to what extent the field of meaning is being reduced or narrowed. In the example of the Germanism *brile < Brille*, which has already undergone narrowing in the number of meanings, further narrowing in the meaning field is shown.

In the German language, according to Duden, the original word *Brille* has two main meanings.[11] The first meaning is *glasses, goggles* and the second meaning is a *toilet seat*. Only the first meaning was adopted into the Bosnian language, but over time the field of meaning was narrowed, and the word acquired the narrowed meaning of "sports (e.g., ski) glasses". In the German language, *Brille* has a general meaning of "glasses" and is becoming specific with prefixes such as Schibrille (ski goggles), Schwimmbrille (swimming goggles), Taucherbrille (diving goggles), Schutzbrille (safety goggles), etc., with the fact that in certain contexts only the abbreviated Brille is used.

3.3. Meaning expansion
Meaning expansion is a phenomenon that occurs exclusively in the secondary phase after the primary adaptation and integration of a foreign word into the recipient's language. At this stage, the foreign word can retain its original meaning, but it can also acquire new meanings that do not exist in the language of the donor. This expansion of meaning results in a loss of precision, but also a gain in the breadth of meaning [6]. Therefore, two basic conditions are necessary for the Meaning expansion: complete phonological, morphological, and semantic integration of the loanword into the system of the recipient

[9] Meanings originally taken from dictionary are: 1. spitzes, scharfes Ende von etwas 2. Anfang z.B. der Saison 3. in vorderster Position spielende[r] Stürmer[in], 4. Spitzengruppe 5. Höchstwert, Gipfel 6. bei der Aufrechnung bleibender Betrag 7. gegen jemanden gerichtete boshafte Bemerkung 8. in unterschiedlichen Techniken aus Fäden hergestelltes Material mit kunstvoll durchbrochenen Mustern

[10] Meanings originally taken from dictionary are: 1. aus Garn gewebtes, gestricktes Erzeugnis, das besonders für Kleidung verarbeitet wird 2. Substanz 3. Alkohol oder Rauschgift 4. etwas, was eine Grundlage für künstlerische Gestaltung, wissenschaftliche Darstellung, Behandlung abgibt; etwas worüber jemand berichten kann

[11] Meanings originally from Duden: Bedeutungen: 1. (vor den Augen getragenes) Gestell mit Bügeln und zwei geschliffenen oder gefärbten, der Verbesserung der Sehschärfe oder dem Schutz der Augen dienenden Gläsern; 2. Kurzform für Klobrille (Toilettensitz).

language and its free use within that language. Meaning expansion is therefore exclusively a secondary adaptation of a foreign word into the recipient language.

Secondary semantic adaptation includes the expansion of the number of meanings and the expansion of the field of meanings. Filipović [6] starting from Hope's definition, lists four types of changes depending on the way the meaning changes. Thus, there are four basic types: a) metaphor (similarity in meaning), b) metonymy (connection in meaning), c) folk etymology (similarity in form), d) ellipsis (connection in form).

3.3.1. Metaphor. The first factor is metaphor, which influences the development of the meaning of Germanisms in the Bosnian language. To show the influence, we can use the example of Germanism *štos* < *Stoß*. In the primary stage of adaptation, two meanings were transferred from the German language: "pile" for example a pile of papers or fabric or similar, and the meaning "blow or shot". The second meaning served as a basis for expanding the meaning, i.e., creating a new metaphorical meaning of the word as "trick". In the context of fashion, the word *štos* (trick) or the phrase *dobar štos* (good trick) is used to describe a skill or trick in choosing clothes or style that helps create the visual impression of a different (better) look. In a broader sense, the term *štos* is used to describe an interesting detail, a sudden effect, or an exceptionally good appearance of an outfit or combination. In the Bosnian language, the loanword *štos* is used with all three different meanings. The first two meanings were transferred in the primary adaptation and words with these original meanings became frequent in the Bosnian language, and new metaphorical meaning was created by their productivity in the Bosnian language system.

In addition to the possibility of a metaphorical meaning, the word can remain neutral or acquire a pejorative tone. In most cases, the use of metaphors is followed by pejoration. The new metaphorical meaning of the word *štos* (trick, joke) can also have a shade of pejoration and be used with the meaning of fraud, prank or similar.

Other examples that have, in addition to their original meanings, newly created metaphorical meanings and, depending on the context, sometimes with a shade of pejoration are, for example: *peglati* (main meaning is “to iron” and additional meaning is in the sense “to bother someone, to annoy someone”), *imati klikera* (main meaning is “have a marble” and additional meaning is “to be smart”), *biti fora* (main meaning is “to be cool”, and additional is “to be an important person”), *nasjesti na štos* (fist meaning is “to fall for a stunt” and additional is “to be deceived”), *imati šlaufove oko stomaka* (main meaning is “have a floater around the stomach” and additional meaning is “to have fat around the waist”), *šminker/ica* (main meaning is “make-up artist” and additional meaning is “a person who cares too much about their appearance”).

3.3.2. Metonymy. The German loanword *štap* < *Stab* was adopted into the Bosnian language with the meaning "clip" or "aid tool for work or walking". In this form and with these meanings, the word *štap* becomes active and is subject to change on different levels like any domestic word. In sports terminology, it is often used for different objects, such as *hokejaški štap* (an ice hockey stick), *golf štapovi* (golf sticks), and similar. In these examples, the meaning has been expanded, among other things, under the influence of the metonymy factor, because the objects are related by their similarity and function. By adding the suffix -ić to the Germanism *štap*, which forms a diminutive in the Bosnian language, a new word *štapić* (singular noun) was formed. By adding the suffix -i, plural form *štapići* is formed, in the sense of "snacks with an oblong shape of small sticks". The term *štapić* is used in various compounds with the meaning of "a small stick", such as a magic wand, a conductor's wand... In fashion terminology, aids are used, for example, as props in gymnastics. In the context of fashion, *štap za hodanje* - a walking stick has a meaning as a style element or an accessory to clothing. The word is also used in the context of a stick for holding a parasol or umbrella.

The Germanism *cof* < *Zopf* is used as the name of a hairstyle when the hair is gathered in a ponytail or braid on the top of the head. Under the influence of the factor of metonymy, the meaning and use of the word *cof* with the meaning "bait for (fishing) hunting" has expanded. In this case, that meaning *"cof"* is

related to the word *"Zopf"* (tail hairstyle on the head) through the common characteristic of the shape, that is, the "tail" protrusion on the top of the lure.

In the case of the Germanism of *baletanke* < *Balletschuhe* with the meaning "ballet shoes" there was an expansion of the meaning in fashion jargon. In German, the word *Balletschuhe* is exclusively used for ballet shoes. However, in the Bosnian language it has acquired a wider meaning and describes any comfortable footwear like ballet shoes.

The Germanisms *šminker* and *šminkerica* (make-up artist) were created based on the already adapted word *šminka* < *Schminke* (make-up). The word *šminker/ica* is also used to represent a person who dresses fashionably, who attaches great importance to their clothing and appearance.

Germanism *šnala* and diminutive *šnalica* < *Schnalle* has many meanings in the German language. The first meaning is "a part of a belt, or a buckle in the form of a ring or a similar shape, through which the other end of belt passes". In the Bosnian language, that meaning was taken over, but over time the word *šnala* expanded its meaning and acquired a general meaning that includes different types of hair clips. In German, the word *Haarspange* is used. The word *Haarschnalle* refers to a type of hair clip that has a clip and two pairs of arms and can be opened and closed.

Under the influence of the factor of metonymy, the meaning of the word *štikle* (high heels) also expanded. The word *štikle* in the Bosnian language was formed based on the German word *Stöckel*, which originally meant "shoe heels". In the process of taking over from the German language, the Germanism *štikla* was formed, which became an active word with a new meaning. In the Bosnian language, the term *štikla* is used as a synonym for high heels.

In German, the word *"Stöckelschuhe"* would be used for that concept. This change in the meaning of the word *štikla* is another example of the spread of meaning through metonymy, where a word that originally denotes only one part of a term is used to denote the whole term with which it is associated. In this case, the word *štikla* is used to refer to an entire pair of shoes with a high heel, although the original meaning of the word was only related to the heel of the shoe.

4. Conclusion

We conclude that Germanisms are found in every segment of life, so there is no area where they are not used. In this paper, we focused on Germanisms from the conceptual field of fashion and studied 75 examples that were subjected to the analysis of adaptation processes at the semantic level. The research results of analyzed Germanisms indicate how much more complex the semantic adaptation of Germanisms is compared to phonological and morphological adaptation, given that it is not a matter of mechanical adaptation, but that this area belongs to human linguistic creativity.

The analysis of adaptation processes in the primary phase confirms the assumption that most of the analyzed Germanisms belong to zero semantic extension. Out of a total of 75 Germanisms, 48 words have been adapted into the Bosnian language with one specific meaning, while the other examples have two or three meanings. In the analyzed corpus, we note that in ten cases there was a narrowing of the number of meanings, and in one example an additional narrowing of the meaning field was noticed.

Unlike primary adaptation, where the beginning and end are clearly defined, secondary adaptation is clearly defined when it comes to the formation of a primary replica based on the primary model. The ending cannot be determined, because the replica can change during the development of the Bosnian language. These changes are no longer associated with the German language because they are always bound only within the Bosnian language system and according to its rules. This is proven by the examples of Germanisms in which, in the phase of secondary adaptation, the meaning was expanded using metaphor, metonymy and pejoration.

Out of a total of nineteen Germanisms that experienced a change in meaning after the primary complete adaptation to the Bosnian language system, six examples were recorded where the change was caused by metaphor and six Germanisms whose meanings expanded under the influence of metonymy.

In the end, we can conclude that every Germanism in secondary adaptation becomes a model that can be used for the creation of both new lexemes and new meanings. Therefore, the process of secondary adaptation remains open as long as Germanism is used in the Bosnian language.

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Female medical uniforms design and development of virtual prototypes according to functional and psychological preferences

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Abstract. The uniform is a part of the medical staff identity, which appearance has been affected and modified throughout history in accordance with social changes and status of doctors and nurses. In the context of the textile technologies, uniforms changed with the development of textile materials and clothing engineering, as well as the increasing demands of users for the design of functional and fashionably appropriate models. The main issue of medical uniforms in healthcare institutions of the Republic of Croatia is in the use of non-standardized models, which differ significantly between and within individual institutions in the context of design and the inappropriateness of clothing sizes for staff of different ages and body types. The paper presents research on the preferences and functional requirements of the uniforms for female medical staff of different age groups, sizes and body types, employed in different workplaces in the health care institutions. A survey was conducted with the purpose of establishing guidelines for the design and development of functional models in accordance with the expressed needs. Based on the research results, models of female medical uniforms were computer designed and virtual prototypes were developed, with the purpose of analyzing and verifying the models for users of different sizes and body types.

1. Introduction

The term uniform refers to a standardized form of clothing or a clothing combination, which is automatically associated with a specific position or function performed by the person wearing it, e.g. medical staff, police, fire service, etc. The purpose of uniforms is to express belonging to a profession or function with the aim of distinguishing it from other people, as well as protecting the person who wears it. In accordance with the profession for which the uniform is intended, characteristics such as textile material, color or cutting pattern are adjusted, which must meet basic criteria such as wearing comfort, fit and functionality [1,2].

Throughout history, medical uniforms have followed the form of monk's robes, since nuns were the first to hold positions as medical staff. The order of nurses appeared in the 19th century, while the first official medical uniforms were introduced in the 20th century [3]. Considering the wide range of medical personnel in terms of different occupational segments, age groups and body sizes and shapes, the issue of inappropriate models in terms of design, fit and functionality of clothing items stands out in the field of medical uniforms development. Advances in contemporary technology have made it easier and more economically acceptable to develop and produce clothing. Modern CAD systems for computer 2D/3D

clothing design enable the complete design of computer prototypes for new clothing models with the aim of achieving 3D visualization of the design and conducting fit and functional analysis on different body types [4,5].

2. Development and role of medical uniforms throughout history

The first health institutions were monasteries with nuns as medical staff, which significantly influenced the appearance of future medical uniforms, Figure 1. Nurses dresses were initially made of dark, gray materials, ankle-length, with a white apron and headdress. The headgear, in the form of a white cap, was initially part of hygiene measures and gradually became a nurses trademark, Figure 1, while in the late 20th century they disappeared from use [3]. The order of nurses was established in military hospitals at the beginning of the Crimean War in 1853. The dress code was not strictly defined and different models of aprons were used, as a kind of protection for both patients and staff. Medical schools of church organizations, Figure 1, had a prominent element of the red cross on their uniforms, a veil was added to the cap under which the hair was tied in a tight bun for hygienic reasons, and ranking by color was introduced, with the head nurse wearing a dark uniform and all others white. Differences in uniforms depending on the hierarchy were also introduced by the Washington University Training School for Nurses in 1910th [3]. The young nurses wore short-sleeved uniforms, and the older ones wore long ones with thick hems and colored stripes. During the First World War, the uniform of nurses acquires militaristic features. In order to adapt to bad weather conditions, long dark cloaks with buttons and a waist belt were added to the uniforms. The summer variant of the uniform consisted of a long gray skirt and a white blouse with a high collar, over which a gray military-style cloak with pockets was worn, Figure 1. In the 40s of the 20th century, the uniform became a white shorter dress without an apron, and instead of caps appeared crown-like headdresses. In the 1960s, feminist movements affected the appearance of the uniform and dresses were replaced by white trousers. At about the same time, the uniforms of the staff in the operating rooms are changed from white to green in order to reduce glare during operations [3]. The beginnings of nursing in Croatia appear in 1921 when the Ministry of Health opens the School for Nursing Assistants. The uniform of the assistant nurses consisted of 11 parts based on a dress tightened at the waist with a white collar and headdress as well as the school badge as an identification mark, Figure 1 [6].

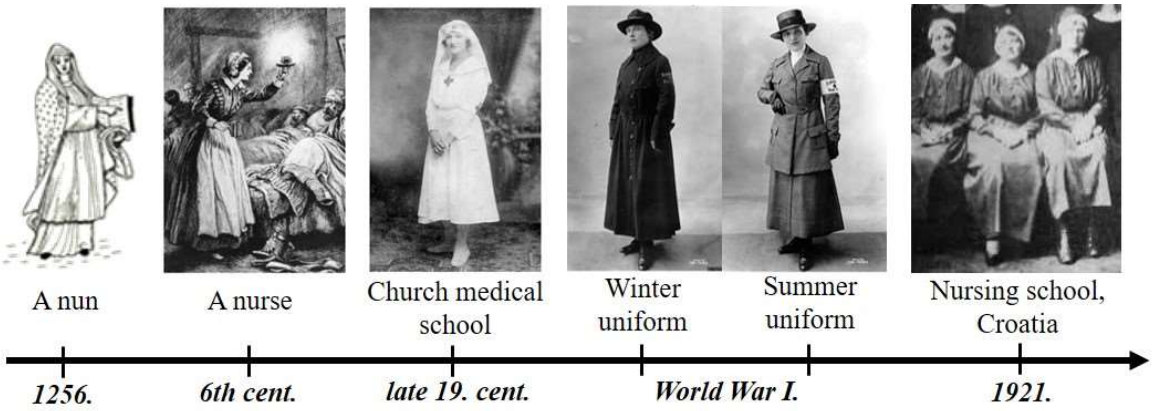

Figure 1. Nursing uniforms history timeline.

2.1. Textile materials and colors of medical uniforms

Cotton materials are most often used for the production of medical staff uniforms, due to their comfort in terms of moisture absorption and good resistance to high temperatures in terms of maintenance, which is very important because of hygienic conditions. Mixtures of cotton with other fibers, most often with polyester in a ratio of 65:35 can also be found in use. Polyester fibers are characterized by good resistance to microorganisms, especially bacteria, which is an additional advantage considering the working conditions of medical personnel. Combinations with a smaller proportion of elastane fibers,

between 2 and 4%, ensure a good fit and stability of garments when worn, considering the great ability of elastic recovery of such fibers after stretching [7].

Research shows that over 90% of a person's first impression is based on visual characteristics such as color, which the brain registers before the text or title, so it is necessary to take into account the basic meaning of colors, their relationship to different disciplines and the influence of certain colors on human physiology and psychology. Based on the first impression, the patient processes information about whether the staff is capable, whether they deserve their trust and whether the patient is willing to allow the staff physical contact. Colors have an inherent meaning associated with emotions, thus becoming a kind of symbols. For example, white represents purity, silence and peace, and as such is most often used for medical uniforms. The traditionally used blue and green colors belong to cool colors that evoke calmness, security and trust which makes them suitable for medical uniforms. The color pink, as an undertone of red, represents the color of young girls and symbolizes tenderness, romance and femininity and can also be found in use for making nurses uniforms. According to research, about 50% of patients perceive the color green as typical for nurses/technicians, while the same percentage associates doctors with light blue [1,8-10].

3. The issue of medical uniforms from the aspect of the clothing sizing systems

The good clothing fit depends not only on the clothing size but also on the body figure. The problems of the industrial serial clothing production, including medical uniforms, are sizing systems that are based on anthropometric measurements of a certain population and do not take into account the figure and posture of the body [11,12], as well as the inconsistency in the marking of sizes between different systems which in particulary highlighted when placing a certain product on different markets. The problems of different clothing patterns construction and grading methods are also highlighted, whereby the method of linear grading between sizes leads to inappropriate fit of clothing on bodies that deviate from normal proportions and body posture [4,11,12]. On different body types, with an increase in size the body does not increase proportionally but a certain part of the body is dominant, for example, with the triangle body type, the lower part of the body increases significantly compared to the upper one, while with the inverted triangle body type the situation is reversed. The construction of a clothing model is based on the designer's idea presented in the form of a sketch or technical drawing, where the body proportions in the drawing and the measurements for the clothing model construction are quite different, and the issue of inappropriate design for certain sizes and body figures comes to the fore [13,14].

3.1. Classification of female body types

With the aim of defining the female body shapes or showing the relationship of individual proportions, the most common symbols used are letters (H, O, A, X, I, S), geometric figures (rectangle, triangle, oval), fruit or different objects (apple, pear , hourglass, spoon, heart) [11]. Each of the groups unites bodies with certain, similar characteristics. The classification of body types is based on the relationship of a set of body measurements, most often the characteristic chest, waist and hips circumferences [15,16]. The usual classification of female body types is into geometric shapes: an inverted triangle with emphasized shoulders and breasts areas, a rectangle with breasts, waist and hips of the same size, an oval with emphasized waist and abdomen and a triangle with emphasized hip area. The hourglass body type is considered a body with ideal proportions in which the circumferences of the breasts and hips are almost the same size and the waist circumference is emphasized and smaller by more than 20 cm [15].

4. Female medical uniforms design and development of virtual prototypes

4.1. Research on the satisfaction and preferences of medical staff on the functionality of medical uniforms

In order to assess the satisfaction of the medical staff with the existing medical uniforms and to investigate the needs and requirements related to the appearance and functionality of the uniform models, a survey questionnaire was created that consists of seven parts: general information, specification of new uniforms, the coat characteristics specification, the blouse characteristics specification, the trousers characteristics specification, the skirt characteristic specification and the tunic

characteristic specification. The survey was conducted on 93 test subjects employed in medical institutions in the Republic of Croatia in different positions. The results of the survey were statistically processed with regard to different age groups and different clothing sizes and body figures in order to design uniforms that meet the functional needs of a particular group of medical personnel based on established preferences.

4.2. Design of new medical uniforms for different female body types according to the preferences and requirements expressed in the survey

From the results of the conducted survey, data on preferences related to the appearance of medical uniforms and requirements in terms of functionality was collected. Based on the collected data technical drawings of coats, pants and blouses models were created for each of the five defined female body types. When designing the models, the cutting pattern elements were considered from the aspect of customization and visual correction of individual body figures. Visual corrections imply a design that emphasizes a particular body part using cutting pattern elements in order to achieve a balance in the proportions between the upper and lower body and thus visually corrects the figure [13,14]. Figure 2 shows the front and back side technical drawings of the coat, blouse and pants for the rectangle body type.

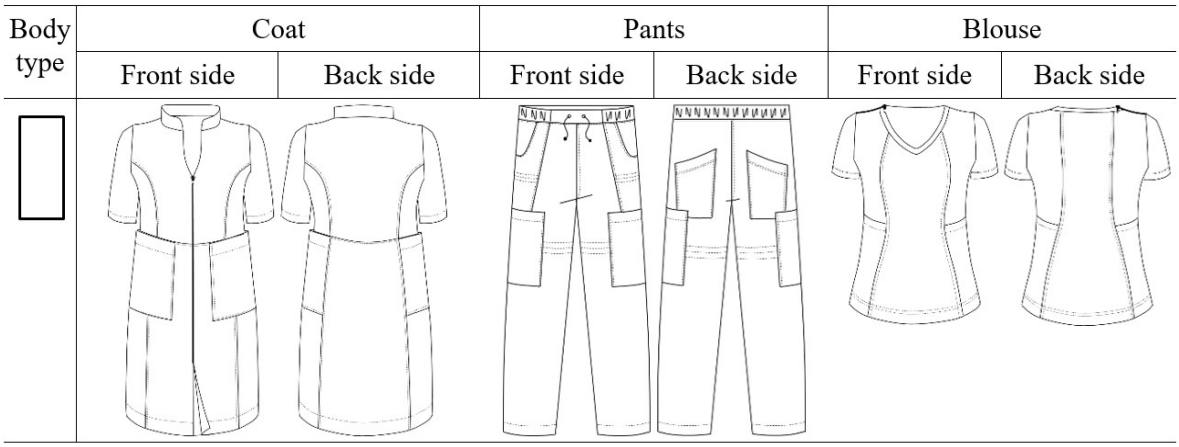

Figure 2. Technical drawings of medical uniform garments for rectangle body type.

4.3. Computer 2D/3D design of new medical uniforms and development of 3D model prototypes for different body types

The basic cutting patterns construction and customization according to body figures was performed in base size 40, Figure 3a). Based on the designed models technical drawings the modeling of the coat, blouse and pants cutting parts, as integral parts of medical uniforms, was conducted, Figure 3b). Computer parametric body models were customized according to specified body figures, Figure 3c) and all necessary parameters for performing 3D simulations are defined on the modeled cutting parts, including positioning of cutting parts around the body model and control of the defined joining segments of the modeled garments Figure 3e).

The physical and mechanical properties of the textile material intended for the production of designed garments were applied to the cutting parts, Figure 3d) in order to enable the ease allowance and fit analysis of the cutting patterns on a particular body figure type. The composition and properties of the applied textile material corresponds to the requirements for more fitted uniform models, expressed in the conducted survey, Table 1. After defining all necessary parameters, 3D simulations for all medical uniforms and garments models combinations were performed on correspondent body models, followed by the fit analysis of the developed 3D prorotypes, Figure 3f).

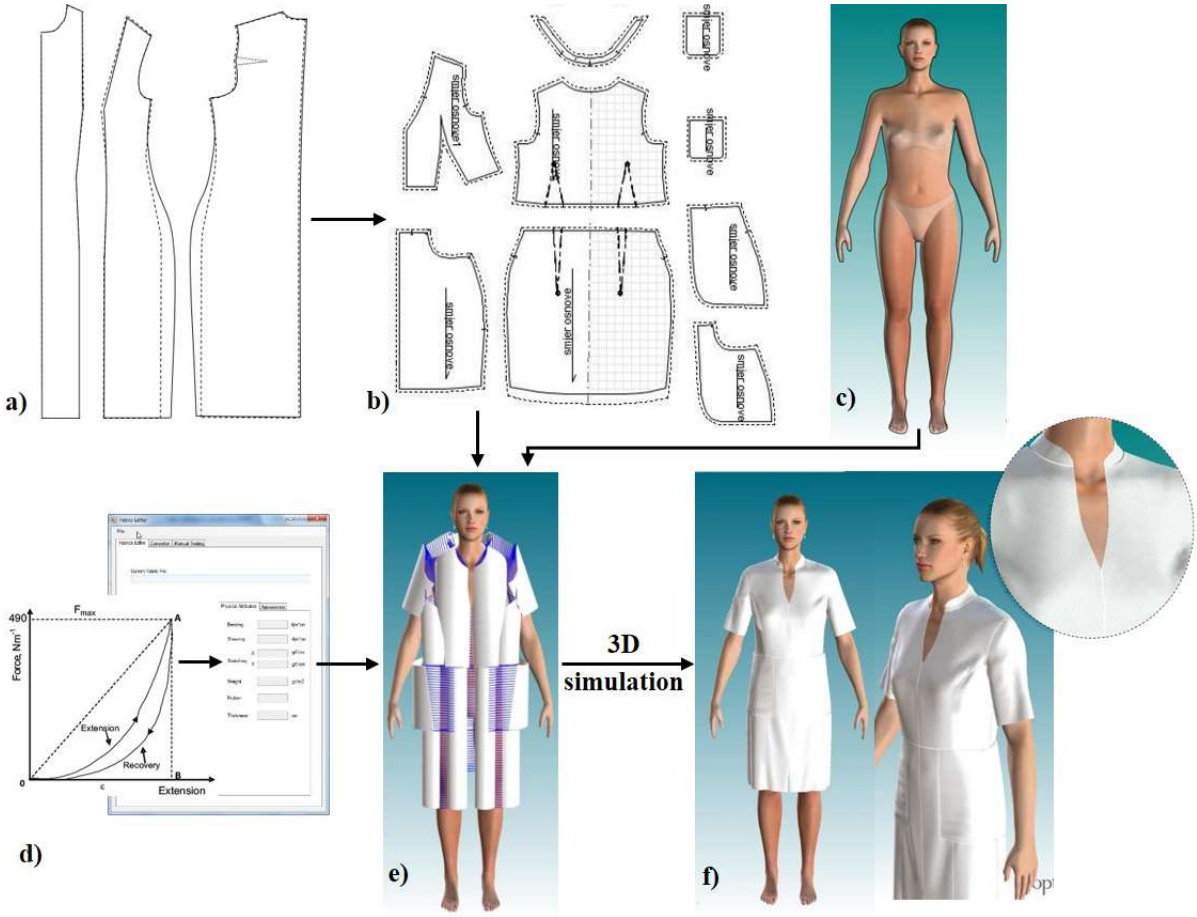

Figure 3. Methodology of 2D/3D design and development of medical uniforms 3D prototypes: a) basic cutting pattern construction and size adjustment according to the body figure type, b) modeling of the cutting parts, c) customization of the computer parametric body model according to the figure type, d) application of textile material properties, e) defining simulation parameters, f) computer 3D prototype of the medical uniform model.

Table 1. Characteristics of textile material for medical uniforms simulations.

		Parameters of physical and mechanical properties						
		Tensile properties		Bending properties		Shear properties	Compression properties	Weight
Material composition	Type	EMT – x[a] [%]	EMT – y[b] [%]	B – x[c] [cN*cm]	B – y[d] [cN*cm]	G[e] [cN/cm]	T0[f] [cm]	W [g/m^2]
98% cotton 2% elastan fibers	Twill	3,480	21,150	0,074	0,037	1,26	0,996	253,0

[a] Tensile elongation in the warp direction at a load of 490 cN/cm
[b] Tensile elongation in the weft direction at a load of 490 cN/cm
[c] Bending rigidity in the warp direction
[d] Bending rigidity in the weft direction
[e] Shear rigidity
[f] Fabric thickness

5. Results

5.1. The results of a survey on the preferences and requirements of medical personnel regarding the functionality and appearance of medical uniforms

Among the test subjects, the largest number are nurses who, considering the job description, have the greatest need for a functional uniform. Dissatisfaction with textile material, design and body fit of the uniform model, which refers to the ease allowance and size, was significantly expressed between all age groups, Figure 4. Figure 5 presents percentage of dissatisfaction with design and fit according to body sizes. Most of the test subjects chose a uniform with a combination of pants and a blouse while only older age groups chose combination with a skirt, Figure 6. When choosing a textile material, hygiene was in the main criteria, considering the environment of the workplace, and 55.7% of the test subjects chose cotton materials, white in color, which can be maintained by washing at high temperatures (90°C).

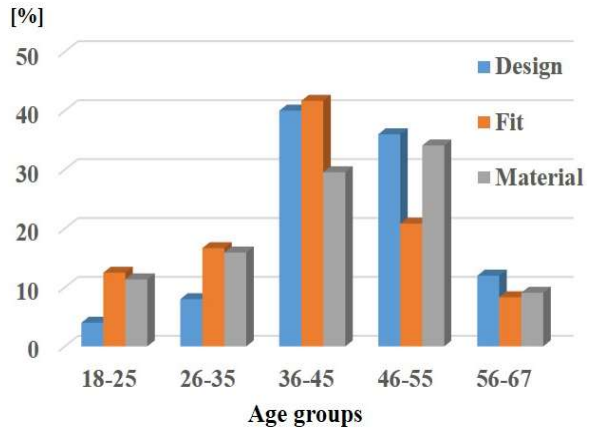

Figure 4. Reasons of dissatisfaction according to age groups.

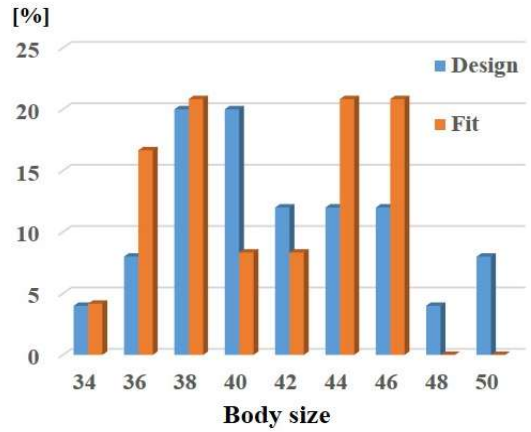

Figure 5. Dissatisfaction with design and fit according to body sizes.

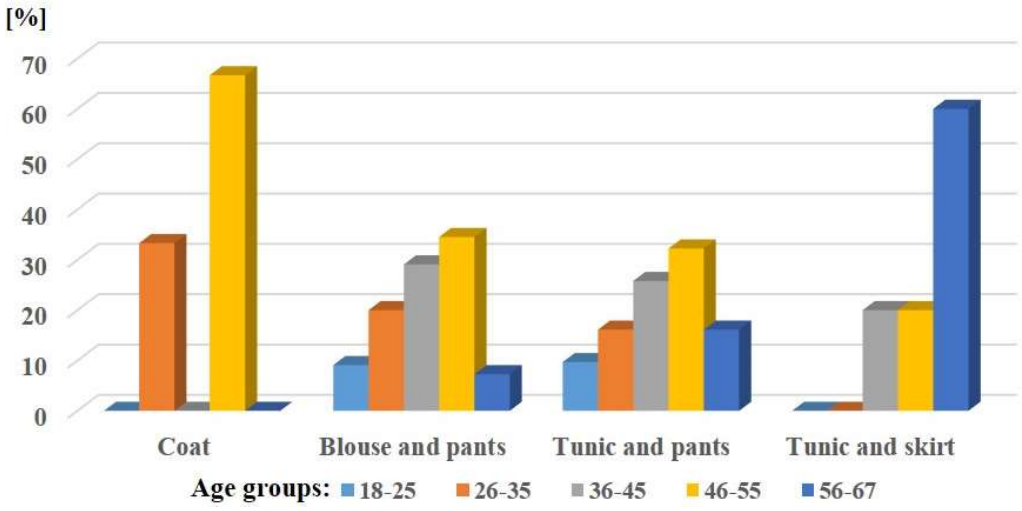

Figure 6. Selection of garment combinations according to age groups.

5.2. The results of new medical uniforms design for five different female body types

The new medical uniforms have been designed for female medical staff with different body figures: hourglass, triangle, inverted triangle, rectangle and oval. Elements and characteristics of uniforms models correspond to the stated requirements for functionality and their appearance is customized according to a particular body figure types in terms of visual correction and achieving a balance in the proportions between upper and lower body.

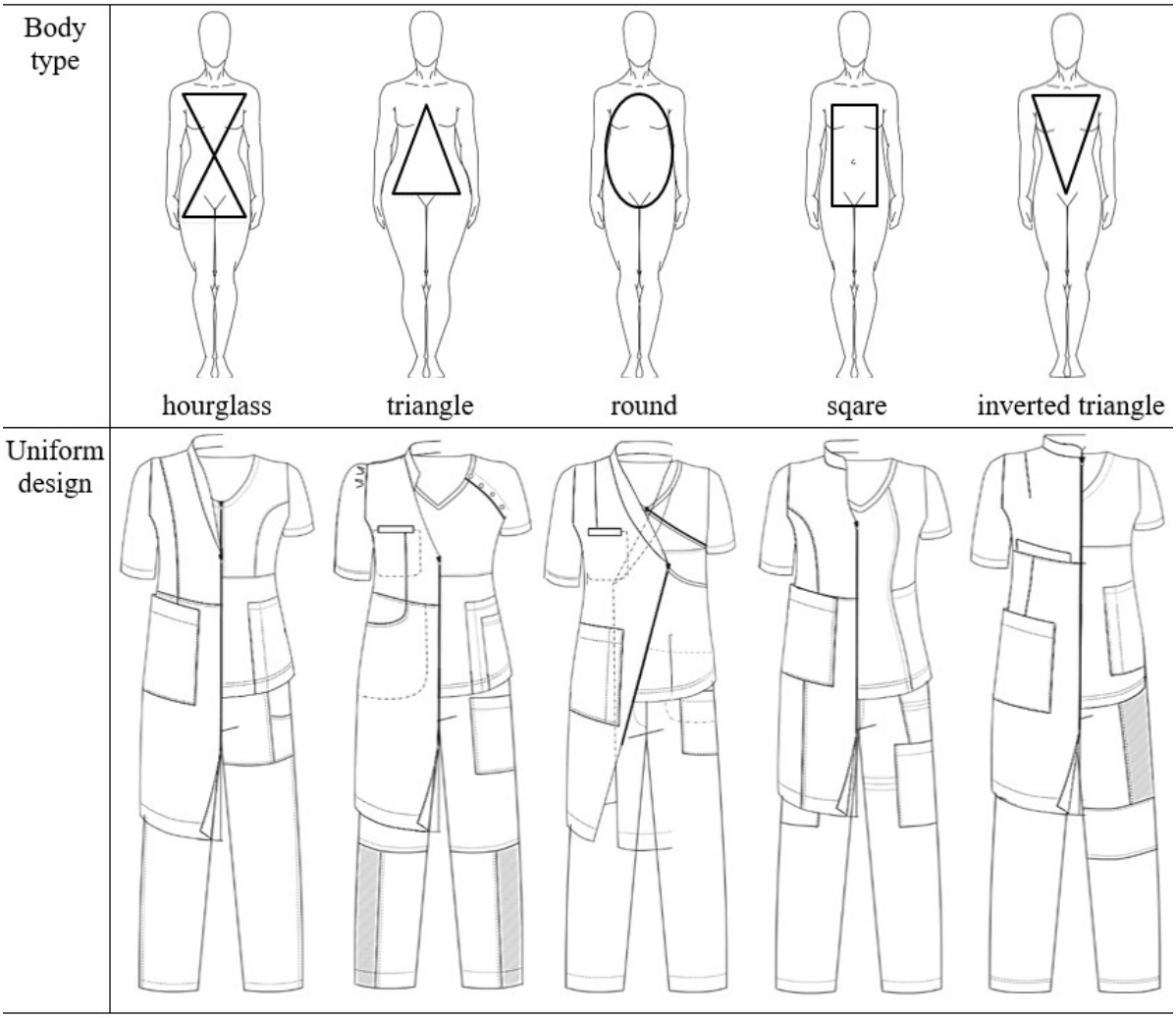

Figure 7. Medical uniform design for different female body types.

In this sense, for the triangle body type, the upper part is emphasized by the volume on the sleeves on the coat model, while the lower part is clean, without prominent cuts and seams. On the blouse model, the top is accented with raglan sleeves with in-seam buttoning, while on the trouser model, cuts and seams on the lower part of the legs are highlighted to visually distract attention from the width in the hip area, Figure 7. For the oval body type, a cutting pattern with a bias flap fastening and a V-neckline with a shawl collar was created. Given that the oval body type corresponds to a larger clothing sizes, the fold, which is slightly narrower than the vertical body line determined by the breast point, visually narrows the figure, while the bias line of fastening in the front center visually breaks the oval shape of the figure. The blouse is cut crosswise below the bust line with a bias fastening from the middle of the V-neckline to the side seam. The accented V-neckline visually lengthens and thereby narrows the figure. The model of the pants has straight legs with bias and sewn pockets in the hips and buttocks area, Figure 7. Given that the rectangular body type does not have prominent body curves, a coat model created for this body type has a waist cut line that visually divides the figure into upper and lower parts. The upper part is emphasized by a curved dividing seam over the breast point that visually shapes the figure in the chest area, and below the waist level there are sewn-on pockets that visually enlarge the hip area. On the model of the blouse, a designed curved dividing seam also visually shapes the figure, while on the pants, a number of differently shaped pockets and cuts were added that highlight the hip area, Figure 7. For the inverted triangle body type, the model of the coat is cut below the bust line, while the hip area is emphasized with patch pockets. The blouse model is also cut below the bust line and pleats are created

for additional volume on the lower part of the torso. The pants model features different cuts and shapes of pockets that emphasize the lower part of the body, Figure 7. Design of the uniform for the hourglass body type fullfils the expressed request of the test subjects for a narrower, waisted model of the coat, which is cut at the waist for further accent of the fit figure. Large sewn-on pockets are positioned below the waistline and a shawl collar has been added to the model. The blouse model also has a waist cut line, with a zipper and pockets positioned at hip level. The trousers are straight-leg with pockets on the hips, Figure 7.

5.3. Results of the new medical uniforms 3D prototypes development for five female body types

According to the methodology presented in section 3.3, Figure 3, 3D prototypes of medical uniform models were developed for five defined female body types, consisting of a combination of blouse, pants and coat garments. The fit of the uniform models 3D prototypes was analyzed in terms of size and ease allowance using the method of transversal plane cross sections on the characteristic body circumferences of the chest, waist and hips, where the comfort was determined from the difference in the ranges between the computer body models and 3D prototypes, Figure 5. On all garment models, the amounts of determined ease allowance correspond to the design of the model and meet the needs for functionality in terms of movement and unrestricted mobility of individual body parts, Table 2. The analysis of fabric stretch in the weft direction has determined the minimum stretching of a 1.24%, on zones where the garment fit closely to the body, which indicates a good dimensional fit of the model, Figure 8.

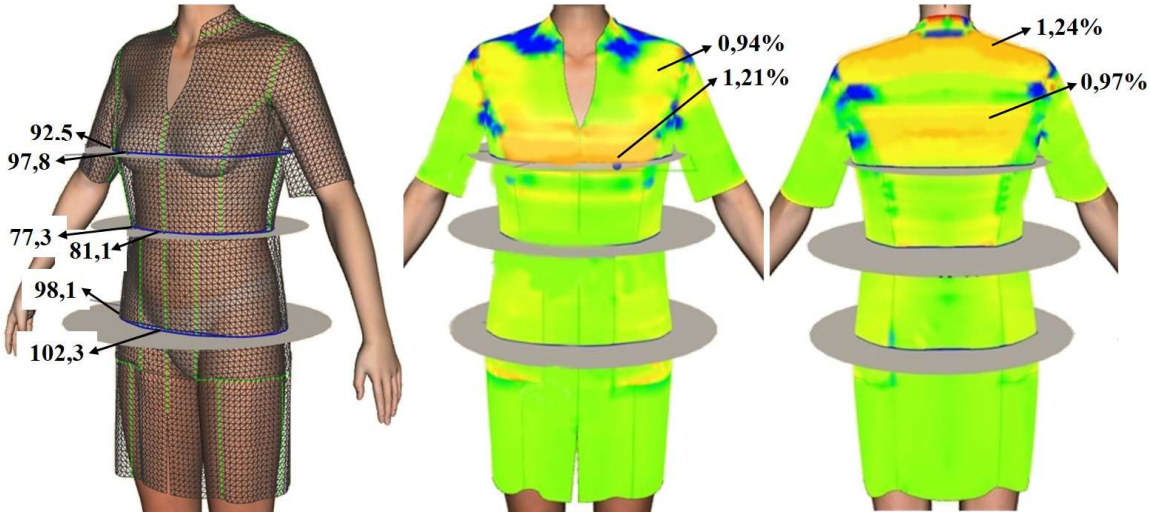

Figure 8. Fit analysis using the transversal plane cross sections method.

Table 2. Calculation of ease allowances on characteristic body circumferences.

Garment model	Characteristic circumference	Cross sections values [cm]		Ease allowance [cm]
		Body	Garment	
Scrub - rectangular body type	Bust	92,5	97,8	4,8
	Waist	77,3	81,1	3,8
	Hips	98,1	102,3	4,2

In the final phase, variations of colors and textures of materials and seams were applied to the uniform models according to the preferences expressed in the conducted survey, with the purpose of visualizing the final appearance of the model, Figure 6. A decorative square element is added to each model of the uniform which can be realized in the form of embroidery or quilting and which additionally emphasizes a particular part of the body depending on the position in which it is placed, Figure 9. The appearance

of the element resembles a Croatian checkerboard and thus indicates the affiliation of the medical staff in terms of standardization at the geographical level. Figure 10 shows the medical uniforms in combination of blouse and pants for the triangle body type, in the virtual environment.

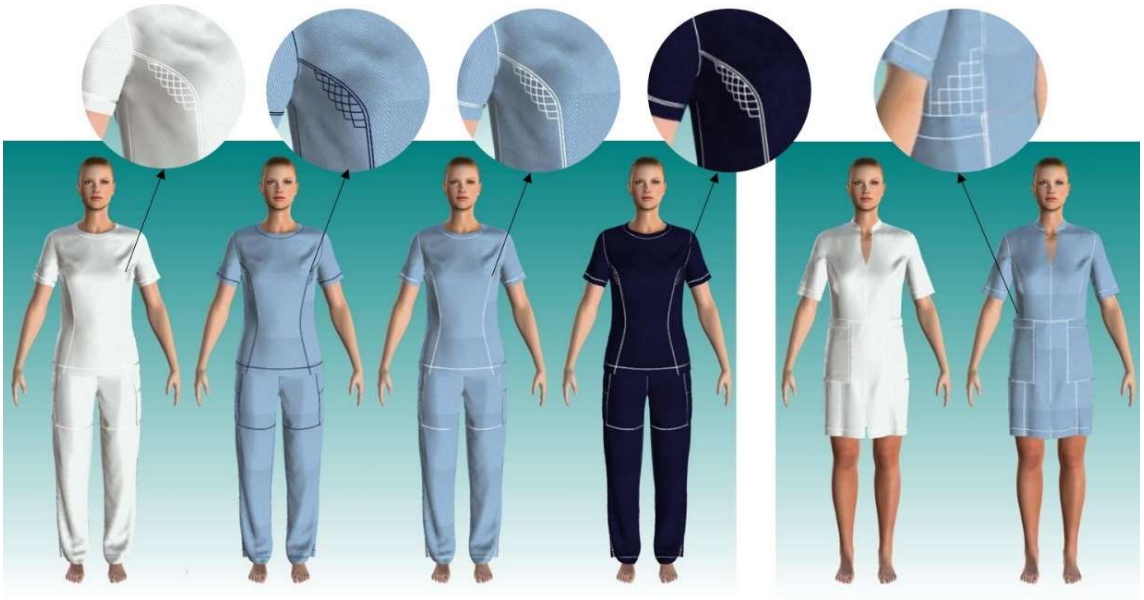

Figure 9. Variations of medical uniforms models for the rectangle body type.

Figure 10. Presentation of the computer 3D prototypes in a virtual environment.

6. Conclusions

Conducting a survey questionnaire is an extremely useful way of gathering information about user preferences and requirements regarding the comfort and functionality of clothing items. According to the results of the survey questionnaire, the greatest dissatisfaction was expressed in terms of clothing sizes and the fit of uniform models. In this sense, the models of the new collection of medical uniforms have been developed and customized for different female body types. There was also an expressed requirement for narrower, waisted models of coats and blouses, which from the aspect of fit requires the use of mixture cotton and elastane fibers textile material but from the aspect of maintenance, such materials do not withstand high temperatures which is very important in medical working conditions for hygienic reasons. Of the preferences related to the design, the need for a greater number of functional

pockets was mostly often expressed, which was implemented in the new models design. When designing, in addition to expressed preferences and requirements, the suitability of the design for different body types in terms of visual corrections was also taken into account. Using different cuts on the pattern and pattern elements, a balance in the proportions of a particular body figures are visually established. The complete development of the new uniforms collection was carried out digitally, from the creation of sketches and technical drawings, construction and modeling of garments 2D cutting parts to the development of 3D prototypes of uniform models shown in Figure 9 and display in a virtual environment as shown in Figure 10.

In addition to speed and precision, computer 2D/3D design is financially more profitable and a more environmentally friendly process of developing new models and collections of clothing compared to conventional construction and the creation of realistic prototypes. The advantage of the 3D prototypes development is significant for this type of research, given the numerous possibilities of visualization and fit analysis of the models on different body types, which in real conditions would require the creation of a very large number of prototypes followed by testing and analysis on human subjects which would require an extremely large amount of time and materials.

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The importance of the clothing size system for the production of women's clothing

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Abstract. The aim of this paper is to create a system of clothing sizes for the female population in the city of Zagreb based on the most important body measurements. Based on this, similarities and differences with the clothing size system of the entire female population in the Republic of Croatia are determined. The system of clothing sizes is established on the basis of the results of anthropometric examinations on a representative sample of a given population, grouping and classifying data on body measurements. In the system of clothing sizes, the individual body measurements, chest circumference and height define the clothing size and form a scale determined by the standard. This research was conducted on a sample of 799 respondents aged 20 to 85 years, divided into seven age groups. Using the method of principal components, the clothing sizes and the representation of certain categories of clothing sizes in the measured population of the city of Zagreb were determined.

1. Introduction

The production of clothing and its successful marketing, taking into account the high functional and aesthetic requirements of customers, is inevitably associated with the establishment of the clothing size system. Such systems enable the production of clothing in sizes that fit most consumers.

Mass production of women's clothing developed from the 1920s. Various factors such as the development of industrial production, the development of the advertising industry, retail chains, and catalogue sales have contributed to the success of this clothing production [1,2].

However, the poor fit to the body shape has led to a weaker interest in industrially produced clothing. Each manufacturer created its own unique and sometimes arbitrary system of clothing sizes. Such a system was often based on incorrect data. Many ready-to-wear sizes confused customers' choices and created additional costs due to the return of inappropriate clothing. The resulting situation increased production costs, which in turn increased customer dissatisfaction. Over time, the original norm became obsolete as both men and women became heavier.

While the average female figure used to conform more to the accentuated narrow waist promoted by fashion magazines, it gradually approached a pear-shaped body with a thicker waist and fuller hips. At the same time that the average woman's body shape was changing, manufacturers were launching larger garments marked with smaller size numbers. This situation suited both manufacturers and customers, and this trend continues today [2,3]. However, in order to solve the emerging problem of clothing sizes no longer fitting an increasing proportion of the population, it was necessary to introduce a true system of clothing sizes based on the measurement of the female bodyAt the beginning of the 20th century, women demanded clothes dictated by fashion trends, which posed a major problem for mass production, as they had to fit the majority of the population. The problem was exacerbated by the artificial modification of the body through the use of corsets.

The problems of making women's clothes that fit the body completely led to the invention of various tools. Stencils and cutting machines were invented that provided the desired body shape in various sizes. However, many of these aids only fit proportional figures.

Moreover, stencils designed for a particular style became useless when the fashion trend changed and a different body shape was required [1,2].

In the first half of the 19th century, the riding jacket was the most important garment for women, for which tailors developed designs and sizes.

In 1897, the American Charles J. Stone published a comprehensive table of proportion measurements. From his chart of figures and drawings, it is clear that the measurements in the table are indeed body measurements, but the proportions are determined by a theoretical approach rather than empirical knowledge. But this was the beginning of the creation of size tables and their use in the design of women's clothing.

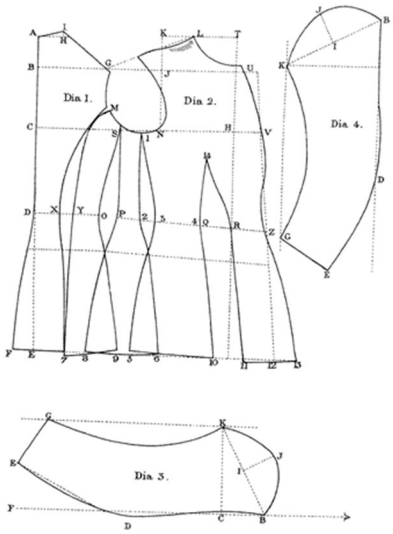

Figure 1. Pattern for a women's jacket based on the proportions of the chest [3].

The European clothing size systems proposed today are based on the existing national clothing size systems, the results of anthropometric measurements of the population over the last 25 years, and the international standards ISO for the marking of garments [1].

2. Proposal for a Croatian size system for women's clothing

Based on the data from the anthropometric survey of the population of the Republic of Croatia (presented in the Croatian Technical Report), it was determined that the basic starting point for the labelling of clothing sizes for women in the Republic of Croatia is the chest circumference, since a statistically significant portion of the population of adult women in the Republic of Croatia has a chest circumference of 76 to 134 cm.

A size range of four cm includes breast circumferences from 76 cm to 104 cm and six cm for breast circumferences from 104 to 134 cm. It follows that the proposal for such a sizing system provides for 13 different bust circumferences for marking women's clothing sizes. The standards specify the range between each age size of eight cm, which determines five different age sizes: 152 cm, 160 cm, 168 cm, 176 cm and 184 cm. Each age represents a range from half of the previous age to half of the next, and in this way the height is represented from 148 cm to 188 cm [4]. The frequency of female clothing sizes for the Republic of Croatia is shown in the table Tab.1

Table 1. Frequency of women's clothing sizes in the Republic of Croatia.

Chest girth	Sample	Body height				
		148-156	156-164	164-172	172-180	180-188
78-82 [a]	n	23	53	49	14	
	%	0,5%	1,1%	1,0%	0,3%	
82-86	n	40	154	166	45	3
	%	0,9%	3,3%	3,6%	1,0%	0,1%
86-90	n	64	276	298	82	4
	%	1,4%	5,9%	6,4%	1,8%	0,1%
90-94	n	78	200	210	91	8
	%	1,7%	4,3%	4,5%	1,9%	0,2%
94-98	n	86	227	247	94	11
	%	1,8%	4,9%	5,3%	2,0%	0,2%
98-102	n	68	242	183	33	7
	%	1,5%	5,2%	3,9%	0,7%	0,1%
102-107	n	109	242	170	31	5
	%	2,3%	5,2%	3,6%	0,7%	0,1%
107-113	n	122	229	141	41	6
	%	2,6%	4,9%	3,0%	0,9%	0,1%
113-119	n	77	124	69	13	2
	%	1,6%	2,7%	1,5%	0,3%	0,0%
119-125	n	35	77	28	5	
	%	0,7%	1,6%	0,6%	0,1%	
125-131	n	16	33	17	3	
	%	0,3%	0,7%	0,4%	0,1%	
131-137	n	2	10	2	3	
	%	0,0%	0,2%	0,0%	0,1%	
137-143	n		1			
	%		0,0%			

In the whole sample, from a total of 57 identified clothing sizes, a percentage of more than 1% of respondents covers 30 of them, which covers 91.5% of the female population of the Republic of Croatia. It was found that the most common sizes with a share of more than 4% are covered by 2171 respondents. The largest number of clothing sizes with a share of more than 1% is in the range of breast circumference from 86 cm to 119 cm in the size categories from 148 cm to 172 cm [2].

3. Material and Methods

3.1. Subjects

This study includes a sample of 799 women from the city of Zagreb. The age of all respondents ranged from 20 to 85 years. According to age, respondents were divided into age groups of ten years, of which there are seven in total, and 0.23% of respondents were included.

The subjects of the city of Zagreb included in this research represent a significant proportion of the total measured population of women in the Republic of Croatia, and the results show the representation of the observed body measurements in the categories prescribed by the Croatian technical report.

3.2. Methods

The measurements required for this research were carried out within the complex technological research and development project "Croatian Anthropometric System" of STIRP HAS, using the standard method applied in similar projects in Europe and the world.

The measurement procedure was performed with anthropometric instruments, a single-arm anthropometer and a measuring tape, in accordance with the standards ISO 3635, ISO 8559 and EN 13402. Two body measurements (height and chest circumference) were taken on a sample of subjects.

3.3.Statistics

The study of the complex system of body measurements on a sample of the female population was performed using the methods of descriptive statistics, which includes the evaluation of the parameters of central tendency (arithmetic mean and median) and dispersion (standard deviation, coefficient of variation, 95% confidence interval, and data range).

In this research, the principal components method helps to verify the method of determining the clothing size system, which is based on the categorization of breast circumference and body size. The results of the analyzes are presented in a table, and the statistical conclusions are accepted with an allowable error of $\alpha = 0.05$. The description and processing of the data was done with the software packages Statistica and SPSS, as well as with the help of specialized literature [5,6].

4. Results and discussion

The parameters of central tendency and dispersion of height and chest circumference were estimated by the method of descriptive statistics. The estimates of the basic parameters are presented in Tables 1 and 2.

Table 1. Basic parameters of the distribution of body height of women (cm) in the City of Zagreb by age.

Region	Age	N [a]	$\bar{x}$ [b]	s [c]	CV [d]	95% CI [e]		Span	
					(%)	h_1	h_2	Min.	Max.
City of	-29	168	166,5	5,9	3,5	165,6	167,4	151,0	**181,0**
Zagreb	30-39	127	165,7	6,8	4,1	164,5	166,9	152,5	**181,0**
	40-49	154	163,7	6,0	3,7	162,7	164,6	148,4	**177,0**
	50-59	110	162,4	6,2	3,8	161,2	163,6	150,5	**179,0**
	60-69	87	162,0	6,9	4,3	160,5	163,4	145,1	**180,0**
	70-79	83	159,2	6,8	4,3	157,8	160,7	140,0	**174,0**
	80-	70	159,6	5,7	3,6	158,3	161,0	147,0	**172,0**
	Ukupno	799	163,4	6,8	4,2	163,0	163,9	140,0	**181,0**

[a] number of cases, [b] arithmetic mean, [c] standard deviation, [d] coefficient of variation, [e] 95% confidence interval

The arithmetic mean of the height of the women is 163.4 cm, the standard deviation is 6.8 cm, the coefficient of variation is 4.2%, and the 95% confidence interval is between 163 cm and 163.9 cm. The lowest height of the subjects is 140 cm and the highest is 181 cm.

Table 2. Basic parameters of women's breast circumference distribution (cm) in the city of Zagreb by age.

Region	Age	N [a]	$\bar{x}$ [b]	s [c]	CV [d]	95% CI [e]		Span	
					(%)	h_1	h_2	Min.	Max.
City of	-29	168	88,5	6,6	7,5	87,4	89,5	78,0	**126,5**
Zagreb	30-39	127	94,0	9,2	9,8	92,4	95,7	77,0	**128,0**
	40-49	154	98,2	9,4	9,6	96,7	99,7	78,0	**129,0**
	50-59	110	102,0	10,5	10,3	100,0	104,0	70,5	**129,0**
	60-69	87	105,1	11,4	10,8	102,7	107,5	83,0	**131,0**
	70-79	83	104,6	11,1	10,6	102,1	107,0	69,0	**131,5**
	80-	70	107,2	11,6	10,8	104,4	109,9	79,0	**127,0**
	Ukupno	799	98,2	11,6	11,8	97,4	99,0	69,0	**131,5**

[a] number of cases, [b] arithmetic mean, [c] standard deviation, [d] coefficient of variation, [e] 95% confidence interval

The arithmetic mean of breast circumference in women is 98.2 cm, the standard deviation is 11.6 cm, the coefficient of variation is 11.8%, and the 95% confidence interval is between 97.4 cm and 99 cm. The smallest chest circumference is 69 cm and the largest is 131.5 cm.

The distribution of certain categories of clothing sizes in the female population of the city of Zagreb is presented below. Although the measured population covers a wider range of clothing sizes, those where the percentage of female respondents is equal to or greater than 1% are included. The frequency of female clothing sizes for the city of Zagreb is presented in a table (Tab. 3).

Table 3. Frequency of clothing sizes for women's clothing in the city of Zagreb.

Chest girth	Sample	Body height				
		148-156	156-164	164-172	172-180	180-188
78-82 [a]	n	4	9	14	3	
	%	0,5%	1,1%	1,8%	0,4%	
82-86	n	8	27	39	11	
	%	1,0%	3,4%	5,0%	1,4%	
86-90	n	10	42	55	8	1
	%	1,3%	5,4%	7,0%	1,0%	0,1%
90-94	n	11	44	38	20	
	%	1,4%	5,6%	4,9%	2,6%	
94-98	n	12	39	26	12	2
	%	1,5%	5,0%	3,3%	1,5%	0,3%
98-102	n	10	46	29	7	
	%	1,3%	5,9%	3,7%	0,9%	
102-107	n	21	34	29	6	
	%	2,7%	4,3%	3,7%	0,8%	
107-113	n	14	36	19	7	
	%	1,8%	4,6%	2,4%	0,9%	
113-119	n	12	16	11	5	
	%	1,5%	2,0%	1,4%	0,6%	
119-125	n	5	13	9	1	
	%	0,6%	1,7%	1,1%	0,1%	
125-131	n	5	7	3	2	
	%	0,6%	0,9%	0,4%	0,3%	
131-137	n		1			
	%		0,1%			

According to the resulting system of clothing sizes for the city of Zagreb, a total of 47 sizes were identified, 32 of which are covered by a share of more than 1% of respondents, which represents 92.3% of the female population of this region. The most frequent sizes with a share of more than 4% are covered by 334 respondents from the mentioned region. Most of the clothing sizes with a share of more than 1% are represented in the range of the bust circumference from 82 cm to 119 cm and the height classes from 148 cm to 172 cm.

5. Conclusion

The determined average values of the most important body measurements of the subjects of the city of Zagreb indicate age-related changes. The results confirm the decrease in height with increasing life expectancy in most age groups. Considered from the youngest to the oldest age group, the decrease in height is 7.3 cm. The mentioned decrease does not occur with the same intensity from the first to the last group, which confirms the slight increase of the value in the last age group. The decrease in height due to the increase in life expectancy is a natural process caused by changes in the human skeleton during aging, and the obtained results determine the actual values of these changes in the studied sample.

According to the research results, the average values of breast circumference increase with age. This is evident in all age groups, except for the age group of 70 to 79 years, where there is a decrease in breast circumference. The difference in breast circumference between the youngest and oldest respondents in the city of Zagreb is almost 20 cm. Based on the above results, a system of clothing sizes for respondents in the city of Zagreb was established.

When comparing the clothing sizes of respondents from the city of Zagreb and respondents from the Republic of Croatia, differences were found, so 10 clothing sizes less were determined for the city of Zagreb than according to the system of the Republic of Croatia, and a proportion of more than 1% of respondents covered two clothing sizes more than according to the system of the Republic of Croatia
The importance of this type of research is confirmed by the problems related to the production and marketing of clothing, which arise due to the large differences in the body measurements of the inhabitants of an area. Identifying the clothing size systems of an individual country, whether on a local, national or international level, provides valuable insights that are useful for both industry and consumers.

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A collection of sustainable fashion from the flora

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Abstract. The flora that surrounds us every day is an inexhaustible source of inspiration, which is reflected in this work. The aim of the work is to revive the ancient methods of dyeing textiles, which have been somewhat forgotten, and to create a collection of clothing in harmony with sustainability. The work describes the method of using natural dyes and the process of transfer printing. In the experimental part, a pattern was made on the fabric using transfer printing on dyed and non-dyed textiles. As a result, the clothing collection "Hamadrijada" was made from textiles dyed with natural dyes in accordance with sustainability.

1. Introduction

In the past, only natural dyes were used for dyeing. Scientists assumed that textile dyeing emerged in China in 3000 BC, but recently a 6200-year-old piece of textile dyed with indigo dye was discovered at George Washington University in Peru. So the practise of dyeing fabrics with natural dyes goes back even further in time [1].

Until the discovery of synthetic dyes in the second half of the 19th century, natural dyes were used. They were cheaper, the color was more intense and there were more possible shades. The use of natural dyes decreased more and more until today synthetic dyes predominate. Awareness of the sustainability and ecological aspects of textile production is reviving the natural dye industry somewhat, but the supply of such products is still small and not sufficiently known to the general public [2].

In recent years, the interest in environmentally friendly fashion products has been steadily increasing. Consumers of fashion products are paying more and more attention to the impact on the environment [3]. Consumer awareness opens the door to slow fashion and promotes sustainable textile production. Slow fashion products are not produced according to the fast fashion business model and usually do not respond to rapid changes in fashion trends. Such products are not tied to seasons, but can be worn for several years. The focus is on product quality and environmental protection [4].

2. Dyeing with natural dyes

Natural dyes are obtained from plant, animal, mineral and microbial sources. The most common are natural dyes from plants, where various parts of the plant, from the fruit to the root, can be used as a dye, depending on the plant. Some examples of dyes from plant sources are onion, pomegranate, turmeric, walnut, oak, dyer's broch and birch. In the case of dyes of animal origin, the most common are

insects [5]. Cochineal is one of the famous types of insects that live on cacti, the females of these insects are used to obtain red dye , then the type of sea snail Murex brandaris or the spiny snail from which purple dye is obtained, one of the most expensive dyes in history. Certain bacteria produce colored substances as secondary metabolites, such as Bacillus, Brevibacterium, Flavobacterium.Natural sources of dyes contain a small amount of dyes with a lot of additional substances such as carbohydrates, proteins, tannins, cellulose, etc.. [5] In order to extract the dye, extraction is done.

Most natural dyes require a mordant, a substance that has an affinity for textile fibers and the dye and serves as a bond between the dye and the fiber. Mordants are most often used in dyeing vegetable fibers that do not have the necessary amino and carboxyl groups that allow the dye molecules to bind to the fiber, unlike animal fibers such as silk and wool that do. There are 3 types of molasses: metal salts, oil molasses, and tannin [5]. Metal salts of aluminum, chromium, tin, copper and iron are most commonly used to dye textiles with natural dyes [5]. When we consider the environmental compatibility of dyeing with natural dyes for the purpose of textile design and clothing collection, it is necessary to pay attention to environmentally friendly metal salts.

Chromium is banned, while copper and tin are allowed, but it is better to use them minimally or not at all, as they still have an impact on the environment in wastewater. Aluminum and iron are environmentally friendly options as they are found in large quantities in nature. By using different metal salts, different shades of color can be achieved for the same dye, which is very important for the designer, as this gives him more room for creativity when designing garments. Dyeing cotton is usually done at boiling temperature, while dyeing wool and silk is done at lower temperatures. Most natural dyes require a neutral pH, but there are dyes that require an acidic or basic solution. For example, when dyeing animal fibers such as wool and silk, 1-2% acetic acid is usually added. The material is first placed in a dyeing solution that is at room temperature, and this temperature is gradually increased to ensure uniform dyeing. In the case of natural dyes, the material must boil in the dye for at least one hour so that the dyes can penetrate the material as well as possible [5].

2.1. Advantages and disadvantages of natural dyes

Natural dyes are considered environmentally friendly because they are derived from renewable resources. They are usually obtained from plant sources. If the dye is used from the fruit or flower, it is harvested without harming the plant, and the food industry also produces large amounts of waste that could be used for natural dyes. The leaves are also a sustainable and renewable source of dyes. When picking leaves, care should be taken to ensure that the amount and frequency of picking leaves from a tree does not compromise its renewal potential. Removing the bark from the tree is a less sustainable method because the bark is removed often and can damage the wood. Textiles dyed with natural dyes provide good protection from UV rays. Many studies have found an improvement in protection from UV rays for cellulosic fibers dyed with natural dyes. In addition, many natural dyes have antimicrobial properties that can be transferred to textiles dyed with natural dyes. There are fewer unpleasant odors when wearing such textiles, which could be due to the antibacterial and bacteriostatic properties of materials dyed with natural dyes. In addition to the advantages, there are also some disadvantages, such as a lengthy dyeing process, a limited number of shades, difficulties in reproducing shades, sensitivity to light and washing, the risk of exploitation of natural resources, and high production costs [5]. The excessive exploitation of natural resources is not in line with sustainability, which means that these dyes are not suitable for mass production.

3. Transfer printing

Transfer printing (eco-printing) is a printing process that uses only natural materials such as leaves, flowers, bark or stems. Transfer printing shows better results on textiles made of natural fibers such as wool or cotton. The best results are achieved on light-colored, undyed fabrics. Cotton fabrics must be boiled first to remove impurities that make it difficult for the dye to be absorbed. An example of transfer printing is printing a leaf on fabric, a relatively simple process. Sheets, previously soaked in a metal salt solution, are placed on a clean cloth. The fabric prepared in this way is wrapped around the cylinder and fastened with string [6].

An additional film may also be placed between the plies as protection before wrapping the cylinder to print the leaf shape on only one side of the fabric and to insulate the fabric from water or water vapor. Then the fabric prepared in this way is boiled or steamed for 2 to 3 hours. After boiling or steaming, the fabric should cool for some time before it is unwrapped. It can be left to cool for several hours, but it is best to let it cool completely overnight. Then the fabric is unrolled and laid out to dry. When the leaves that have left their imprint are removed, it is enough to wash the fabric with a ph-neutral detergent [7]. There are also many variations of this process. For example, rather than soaking the leaves in a metal salt solution, an additional fabric is placed over a clean fabric with leaves that was previously soaked in a metal salt solution, or the fabric on which we want to print the leaves is first dyed with some natural dyes and then soaked leaves are placed on top of the dyed fabric.

Wool and other natural protein fibers like silk and cashmere are good for dyeing with natural dyes. Protein fibers are the easiest to dye because they contain numerous reactive functional groups. They can be dyed with a wide range of colors under acidic, neutral or slightly basic conditions. If you are designing a sustainable clothing collection, it is best to choose organically grown or recycled wool. Cotton is not as easy to dye as protein fibers. Mordants and tanning agents are needed to dye cotton. Some advantages of cotton are that it is biodegradable and recyclable. Also, although cotton is a natural fiber, it is not the best choice for the environment. When choosing cotton fabrics for a clothing collection, it is important to use organically grown cotton from sustainable sources [8].

4. Experimental part

Two methods were used to make the print. One is printing leaves on undyed cloth, the other is printing leaves on dyed cloth. For the first method, leaves rich in tannins and leaves known for their ability to dye were selected. These were leaves of various maple species (e.g., silver-leaved maple, honey maple, and Norway maple), walnut, birch, and red-leaved plum. In addition, the following metal salts were used as surfactants: FeSO4 - 7H2O, iron(II) sulfate heptahydrate and KAl(SO4)2 - 12H2O, potassium aluminum sulfate dodecahydrate. As regulators were used PH: tartaric acid C4H6O6 - for an acidic medium (pH 4), and sodium carbonate (Na2CO3) - for an alkaline medium (pH 8).

4.1 Transfer printing process

The steaming method was used to apply pressure to the fabric. Leaves that have previously soaked in a metal salt solution are placed on the washed fabric, then aluminum foil is placed on top so that the leaves are printed on only one side of the fabric. This is wrapped around a cylindrical bar. Everything is wrapped again with foil to be completely insulated and fastened with string. It is important to wrap the string well and tighten it. The fabric wrapped in this way is placed in a steam pot and steamed for two and a half hours. After steaming, the fabric is wrapped for another 2 hours to cool well.First, it was tested whether it is necessary to soak the textile in an acidic, alkaline or neutral solution. It was tested on cotton and wool. The wool was simply washed by hand with detergent, while the cotton was boiled in water for an hour to remove impurities. Then the pieces were thoroughly soaked in an acidic (5 g tartaric acid per 1 l water), alkaline (5 g sodium carbonate per 1 l water), or neutral (water) solution. The leaves soaked in a ferrous sulfate solution (II) (10 g per 1 l of water) were placed on cloths that were still wet. Then the textile wrapping procedure was applied as previously described [9].

4.2. Transfer printing on dyed textile

Another method is to dye the fabric with a natural dye before adding the leaves. The dye for textiles was obtained by boiling a selected part of the plant until all the dye was extracted. Walnut leaves, pomegranate bark, pine bark and coffee were used as natural dyes. The bark and leaves are boiled in water until they are quite soft (about 1-2 hours). It is then strained to remove plant debris. The textile is placed in the drained dye and boiled for at least 1 hour so that it takes the color well. After dyeing, the textile must be dried to allow optimal printing. It is important not to wash the dyed textile, but only to dry it. The dry-dyed textile then goes through the same process as the undyed transfer print [9].

5. Results

The best results were obtained with textiles that were completely dry before steaming and remained dry after unpacking. It is important to insulate the fabric well before placing it in the pot to prevent moisture from entering. If water were allowed to enter the rolled-up tissue, the print would spill. The length of time the sheets had to soak in the mordants was studied. A neutral, dry textile with leaves soaked for 10, 30 and 60 minutes was placed on the pair. The pressure of the leaves soaked for 10 minutes was slightly weaker, while there was not too much difference in the leaves soaked for 30 and 60 minutes. In addition to ferrous sulfate (II), potassium aluminum sulfate dodecahydrate was also tested. The leaves are soaked in aluminum-based mordants. The leaves were soaked for 45 minutes. The results were significantly worse compared to iron(II)sulfate.

After each steaming, the resulting print was washed by hand in lukewarm water and detergent (1 g per 1 l of water) to remove all leaves and paint residues.

Figure 1. Leaf print on non-dyed fabric.

Of all the dyes tested, the pomegranate dye stands out the most. It reacts immediately on contact with mordants (ferrous sulphate (II)). It is also possible to use a leaf that does not leave an imprint. In addition, the leaves do not have to remain in the water for a long time to obtain a detailed imprint. As with the previous process, the textile is washed by hand after steaming to remove impurities and excess dye. Textiles dyed with pomegranate turned dark after washing.

Figure 2. Transfer print on pre-dyed fabric, on the right side of the fabric darkened after washing.

5.1.Clothing collection Hamadrijad

The inspiration for the clothing collection is flora, especially forest and leaves, which are the main motif on the textiles. The collection consists of classic garments such as skirts, shirts, jackets and trousers, with small innovations that try to imitate trees, as all prints are made with leaves of trees. This is how the collection got the name Hamadriad. The word comes from Greek mythology. Hamadryads are tree nymphs who are born and die together with the tree they are bound to. Besides the cut, the main motif consists of natural dyes and printing leaves.

Figure 3. Collection Hamadriad drawings

To create the pattern on the fabric, only transfer printing was used on undyed fabrics and fabrics dyed with pomegranate peels. The materials used are 100% cotton or wool. The collection is youthful and playful. The garments can be combined with each other, but also with other garments. Fewer garments but more possible combinations are the hallmarks of a good slow fashion collection. Figure 4

Figure 4. Clothing collection Hamadrijad

6. Conclusion

Natural dyes and their benefits not only for the environment but also for human health have been neglected for a long time. This work has shown that it is possible to create a modern clothing collection in line with sustainability using natural dyes and transfer printing. Natural dyes are a renewable resource and, if used wisely, have no harmful effects on the environment. Clothing dyed with natural dyes can be made modern, attractive and in accordance with sustainability and presented as a slow fashion collection. The disadvantage could perhaps be the price of the product, which would be a bit more expensive, but the quality of the product in line with sustainability and the timeless design should be an incentive for the customer to choose such a product.

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[8] K.Fletcher, 2014 *Sustainable Fashion and Textiles*, Routledge, London, 14

[9] Jana Filipčić 2021 Projektiranje kolekcije ženske odjeće inspirirane florom i održivosti u modi University of Zagreb, Faculty of Textile Technology

The calculation of the time norms for the medical protective work blouse model "*Sara*"

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Abstract. The paper calculates the time norms for the specific technological operations during the sewing of the women's work blouse model "Sara", which is used by medical professionals for protection against pollution and various secretions at work. A sketch of the selected model is shown (front and back) and a brief description of the model is given. Also, the technological operations plans for cutting, sewing and finishing of the women's work blouse "Sara" are presented. In addition to the pictorial representations of specific technological operation, calculations of normal times (t_n), actual times (t_s), ideal times (t_i) and unit times (t_l) are given based on the basic time (t_o) recorded for each specified technological operation by folw-through method. Recapitulating the production time of the technological processes of tailoring, sewing and finishing, the total time of the product unit for the women's work blouse model "Sara" is 2327.7 sec.

1. Introduction

The human body is exposed to various hazards during the work process that can be reduced, eliminated or prevented by protective work clothing. Protective work clothing provides protection between the human being and the environment, while also regulating his body temperature. The production and testing of new materials involves high costs due to the need to test various parameters that make up protective workwear, such as wear resistance, chemical resistance, resistance to static electricity, washability, thermal behavior, moisture absorption, and physical properties. Workers exposed to the harmful effects of technological processes (dirt, dust, high temperatures, etc.) should have appropriate protective clothing to protect them during the work process. Workers exposed to the harmful effects of technological processes (dirt, dust, high temperatures, etc.) should be protected by appropriate protective clothing during the work process [1].

Council Directive 89/686/EEC (Council Directive 89/686/EEC, 1989) is a technical document prescribing the use of protective equipment and clothing, according to which the Croatian standard HRN EN 340:2004 is recognized, according to which protective clothing is defined as clothing that covers or replaces personal clothing and provides protection against risks. The basic requirements according to the standard HR HRN EN 340:2004 are harmlessness, design and comfort [2].

In order for protective clothing to effectively protect workers throughout the day, the material, cut, colour, flexibility, comfort, wrinkle, stain and wear resistance must be adjusted [3]. For special working

conditions, there are legally established standards for personal protective equipment, and this protective equipment must have special markings, documents and tested materials that prove the required protection [2].

The paper includes an example of calculating time standards for medical workwear that protects medical personnel from contamination and contact with patients' body fluids.

2. Medical workwear

Medical textiles belong to the group of technical textiles represented in medicine as work and protective clothing, bedding or in various forms used on the patient's body (from filters to implants). The materials used in the production of medical protective workwear must not be carcinogenic, toxic or allergic and should be sterilizable without changing their physical and chemical properties [4].

Medical protective work clothing is divided into personal clothing and clothing used in operating rooms. The colour of protective work clothing allows for better differentiation of the level of training within hospital staff, e.g., physicians wear white work clothing, nurses and technicians wear light or dark blue clothing, while staff in operating rooms usually wear green clothing. In operating rooms, surgical gowns are used to protect medical staff, providing a barrier between sterile and non-sterile surfaces and protecting against body fluids during surgery. In addition to gowns, surgical hoods, masks, shoe covers and gloves are also used (Fig. 1).

Protective caps | Protective face masks | Protective gloves | Protective footwear

Figure 1: Medical protective equipment and footwear [5-8].

Medical professionals select protective work clothing based on aesthetic, ergonomic, and physiological considerations [4].

3. Experimental part

The experimental part shows a technical drawing for the women's blouse model "Sara", which is part of the protective workwear for medical personnel (Fig. 2). It is followed by a brief description of the model and plans of technological operations for the technological processes of tailoring, sewing and finishing. Also, the pass and return method for recording time standards are described and mathematical expressions for calculating the unit of time (t_1) are given.

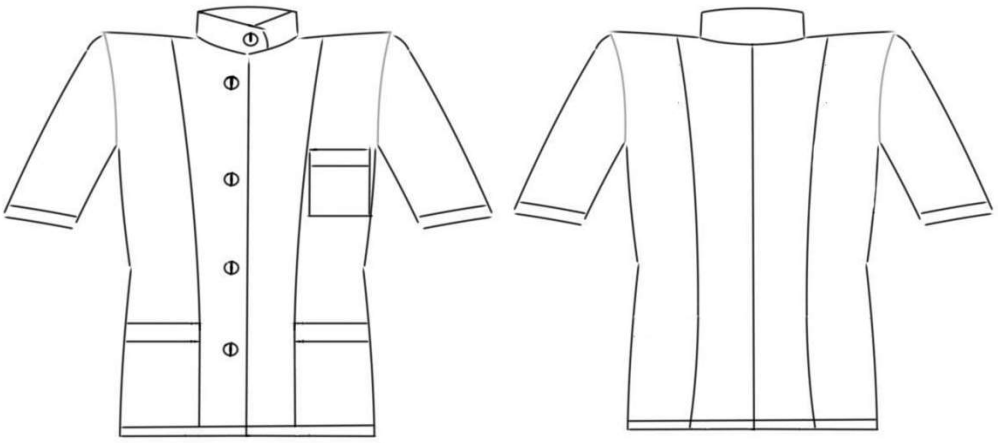


Figure 2. Technical drawing of the model women's work protective blouse "Sara"[9].

Description of women's work blouse model "Sara": women's work blouse with single row closure with five holes and five buttons. Three pockets are sewn on the front. Two larger pockets are sewn on the left and right side at waist height, one smaller pocket is sewn on the left side at chest height. The front and back parts are made of four pattern pieces. Short sleeves made of two pieces are sewn to the work blouse. The stand-up collar is the so-called Russian collar [8].

Table 1. Plan of technological operations for cutting the women's work blouse model "Sara" [9].

Number of techn. operat.	The name of the technological operation	Designation of means of work	Designation of the work category
1.	Laying the base fabric	psp	II
2.	Transferring the cut image to the cut overlay	srr	III
3.	Cutting with a machine with an impact knife	sun	I
4.	Marking of constituent points	sot	I
5.	Assembling bundles	sss	IV

Where is:

psp - semiautomatic table for laying cutting layers
srr- means of manual work
sun - machine with a striking knife
sot - machine for marking component points
sss- table for assembling bundles

Table 2. Plan of technological operations for seawing the women's work blouse model "Sara" [9].

Number of techn. operat.	The name of the technological operation	Designation of means of work	Designation of the work category
1.	Quilting of the pockets	ušs	II
2.	Sewing the lower pockets on the front right and left part	ušs	II
3.	Connecting the front parts	sšs	II

4.	Connecting the back parts	sšs	II
5.	Making a decorative seam on the front parts	ušs	II
6	Sewing the upper pocket on the front left part	ušs	II
7.	Sewing the shoulder seam	sšs	II
8.	Sewing the sleeves into a sleeve circle and joining the side parts of the blouse	sšs	II
9.	Making hems on the fronts (for the flap)	sšs	II
10.	Making the collar and turning it	ušs	II
11.	Sewing the label in the middle of the back part	ušs	II
12.	Sewing the collar in cervical the cutout	ušs	II
13.	Closing the collar and making a decorative seam	ušs	II
14.	Making a hem along the length	ušs	II
15.	Making hems on the sleeves	ušs	II

Where is:

ušs - universal sewing machine
sšs- special sewing machine

Table 3. Plan of technological operations for finishing the women's work blouse model "Sara"[9].

Number of techn. operat.	**The name of the technological operation**	**Designation of means of work**	**Designation of the work category**
1.	Making the holes	šau	I
2.	Sewing on the buttons	šau	I
3.	Cleaning of the thread	srr	III
4.	Quality control	srr	III
5.	Stacking and packing	srr	III

Where is:

šau - automatic sewing machine
srr- means of manual work

3.1. Time norms

Measurement and analysis of time norms is carried out by means of work study methods and methods of given times. The study of works is a scientific discipline that deals with the planning, organization and rationalization of production, as well as the collection, analysis and evaluation of data that serve as a basis for the design of workplaces, the selection of work equipment, machines and tools necessary for the worker to work unhindered at his workplace and perform and execute work tasks [10-12].

To record the time of a technological operation, instruments are used that allow easy and accurate reading of the time, namely stopwatches or chronometers, time devices, and video cameras. A chronometer is a device for recording basic manufacturing time that can be divided into two groups based on the values displayed: a chronometer in which the minutes are divided into 100 divisions (centi hurra) and a chronometer in which the hour is divided into 10 000 divisions (dmh hurra) [10].

3.2. Methods of recording with stopwatches

There are two methods for measuring time with a chronometer: the flow-though method and the returning method. In the flow-through method, the stopwatch is activated at the beginning of the

recording and turns off only at the end of the recording. The time of each operation is read while the hand is in motion, which requires high concentration and training of the recorder. After recording, the base time for each operation is calculated. In the return method, the time is read after the operation is completed, the stopwatch is returned to the home position, and the procedure is repeated for each operation [12].

In the return method, the watch hand returns to its original position by pressing the crown after reading the time of each operation, so that the basic times are recorded immediately and do not have to be calculated subsequently. In this method, two stopwatches are used, one of which is a working watch used to read the time of the operation, and the second is a control watch that is turned on at the beginning of the recording and turned off at the end of the recording, and the total time is obtained. The basic times are determined immediately in the return method, i.e. they do not have to be calculated subsequently as in the flow though method [10].

The advantages of this method are that recording errors can be observed during the recording itself and the recording can be interrupted and resumed at any time.

The measurement of the basic times of technological operations was performed in this paper using the flow though method. The specific technological operations of the technological sewing process were singled out, for which the time norms were calculated. The specific technological operations, the basic time (t_o) was recorded for certain technological operations and then the other times were calculated:

t_n - normal time,
t_s - real time,
t_i - ideal time,
t_1 - unit time [10].

To calculate the unit time (t1), the following data are needed:

K_{pz} - coefficient of commitment of assessment;
K_n - fatigue coefficient;
K_a - coefficient of environmental impact;
K_d - additional coefficient of additional time [10].

The normal time is calculated using a mathematical expression:

$$t_n = t_0 \cdot K_{pz} \tag{1}$$

The coefficient of commitment of assessment (K_{pz}) is given on the basis of the subjective estimation of the recorder. For specific technological operations of the specified model of protective work blouse "Sara" K_{pz} is in the range from 0.9 to 1.1.

The actual time is calculated using a mathematical expression:

$$t_s = t_n \cdot (1 + K_n \cdot K_a) \tag{2}$$

The fatigue coefficient (K_n) in the value of 0.11 was determined taking into account the surface mass of materials and fatigue of workers during the performance of technological operations.

The environmental impact coefficient (K_a) is influenced by temperature and relative humidity. For the calculations of weather standards, the value of the environmental impact coefficient of 1.0 was used.

To calculate the ideal time, it is necessary to add up all the actual times, which is represented by the mathematical expression:

$$\sum t_s = t_i \tag{3}$$

The unit time of a technological operation is calculated using a mathematical expression:

$$t_1 = t_i \cdot (1 + K_d) \tag{4}$$

The additional coefficient of additional time represents the losses incurred by the worker due to thread changes, needle changes, waiting for material, personal needs, etc. [10].

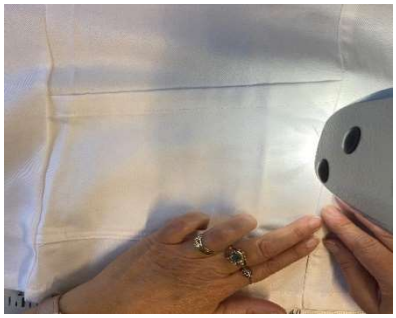
For the calculation of time norms in this paper, the K_d value of 0.12 was used, which was determined by the method of current observations.

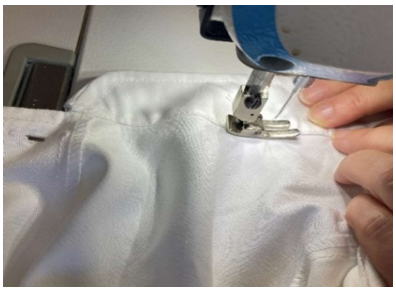
4. Results and discussion

In the results of the work, a pictorial representation and calculations of time norms of specific technological operations of sewing women's blouse model "Sara" from a real production plant are presented.

Specific technological operations for the technological process of sewing women's blouse "Sara" are presented in Tab. 4 together with the previously mentioned coefficients K_{pz}, K_n, K_a i K_d.

Table 4. Time norms for the technological process of sewing the women's blouse "Sara" [9].

The name of the techn. operation	A pictorial representation of the technological operation	The calculation (t_1)
Sewing the lower pockets on the front right and left part		t_o = 98,26 s K_{pz} = 1.0 $t_n = 98.26 \cdot 1.0 = 98.26\ s$ t_n = 98.26 s K_n = 0.11 K_a = 1.0 $t_s = 98.26 \cdot (1 + 0.11 \cdot 1.0) = 109.069\ s$ $\sum t_s = t_i = 109.069\ s$ K_d =0.12 $t_1 = 109.069 \cdot (1 + 0.12) = 122.16\ s$ $\boldsymbol{t_1 = 122.16s}$
Connecting the front parts		t_o = 50.8 s K_{pz} = 0.90 $t_n = 50.8 \cdot 0.90 = 45.72\ s$ t_n = 45.72 s K_n = 0.11 K_a = 1.0 $t_s = 45.72 \cdot (1 + 0.11 \cdot 1.0) = 50.749\ s$ $\sum t_s = t_i = 50.749\ s$ K_d =0.12 $t_1 = 50.749 \cdot (1 + 0.12) = 56.84\ s$ $\boldsymbol{t_1 = 56.84\ s}$
Sewing the sleeves into a sleeve circle and joining the side parts of the blouse		t_o = 100.6 s K_{pz} = 0.95 $t_n = 100.6 \cdot 0.95 = 95.57\ s$ t_n = 95.57 s K_n = 0.11 K_a = 1.0 $t_s = 95.57 \cdot (1 + 0.11 \cdot 1.0) = 106.083\ s$ $\sum t_s = t_i = 106.083\ s$ K_d =0.12 $t_1 = 106.083 \cdot (1 + 0.12) = 118.81s$ $\boldsymbol{t_1 = 118.81\ s}$
Making the collar and turning it		t_o = 45.8 s K_{pz} = 1.0 $t_n = 45.8 \cdot 1.0 = 45.8\ s$ t_n = 45.8 s K_n = 0.11 K_a = 1.0 $t_s = 45.8 \cdot (1 + 0.11 \cdot 1.0) = 50.838\ s$ $\sum t_s = t_i = 50.838\ s$ K_d =0.12 $t_1 = 50.838 \cdot (1 + 0.12) = 56.94\ s$ $\boldsymbol{t_1 = 56.94\ s}$

Sewing the collar in cervical the cutout		t_o = 30.11 s K_{pz} = 0.9 $t_n = 30.11 \cdot 0.95 = 28.605\ s$ t_n = 28.605 s K_n = 0.11 K_a = 1.0 $t_s = 28.605 \cdot (1 + 0.11 \cdot 1.0) = 31.75\ s$ $\sum t_s = t_i$ =31.75 K_d =0.12 $t_1 = 31.75 \cdot (1 + 0.12) = 35.56\ s$ $\boldsymbol{t_1 = 35.56\ s}$

Tab. 5 shows the recapitulation of production time by technological processes in the production of women's blouse "Sara", and the total production time is calculated.

Table 5. Production time according to technological processes [9].

Technological process of cutting	1147.1 s
Technological sewing process	1022.84 s
Technological process of finishing	157.76 s
Total time	$\boldsymbol{t_{kr} + t_{šiv} + t_{dor}}$ **= 2327.7 s**

The total time for the production of the women's blouse "Sara" is 2327.7 seconds.

5. Conclusions

The aim of the work was to create a technological analysis and determine the time norms of the selected model of women's work blouse "Sara". In addition to making a sketch of the selected model, pictorial representations and calculations of time norms for specific technological sewing operations are given below:

1. Sewing the lower pockets on the front right and left part t_1=122.16s
2. Connecting the front parts t_1=56.84 s
3. Sewing the sleeves into a sleeve circle and joining the side parts of the blouse t_1=118.81 s
4. Making the collar and turning it t_1=56.94 s
5. Sewing the collar in cervical the cutout t_1=35.56 s

In order to calculate the time norms of the above technological processes, data are required for K_{pz} (ranging from 0.9 to 1.0), K_n (a value of 0.11 was read from the tables taking into account the surface mass of the materials and the fatigue of the workers), K_a (1.0 based on the temperature and relative humidity) and K_d (of 0.12, obtained by the method of ongoing observations).
By recapitulating the production time, a total production time of 2327.70 seconds was obtained for the selected model of women's work protective blouse "Sara".

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Antibacterial properties of nano silver

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Abstract. Nano silver (silver in the form of nanoparticles) possesses significant antibacterial properties, making it a subject of great interest in the field of medical and health technologies. These properties stem from the specific characteristics of nano silver that enable effective interactions with bacteria. In this abstract, we explore the antibacterial specifications of nano silver, its mechanisms of action, medical applications, and potential challenges and future perspectives.

1. Introduction

Over the past 120 years, numerous studies have been conducted focusing on the chemistry of silver nanoparticles and their antimicrobial applications. Silver's role as an antibiotic and sterilizer has been extensively discussed in numerous books, drawing on human experiences dating back 1200 years when European and global nobility attributed their health and strength to silver. Viruses and bacteria remain the most common causes of diseases. Considering that viruses can survive on object surfaces for up to 48 hours, protection against microbial degradation and contamination has long been a subject of human interest. Modern silver technology has experienced a new resurgence due to its versatile range of applications. Nanotechnology has enabled the continuous release of positively charged ions from very small silver particles, effectively destroying over 650 species of viruses, bacteria, fungi, and parasites within a few minutes. Additionally, nanotechnology has found applications in the textile industry, which plays a vital role in medicine [1].

2. Theoretical part

The first thought on nanomaterials and what makes them special is that their physical and chemical properties can differ from materials of the same kind but with macroscopic dimensions. Simply put, these objects behave differently just because they are small. This opens up enormous potential for creating entirely new material properties by manipulating the size of nano-objects [2]. The term "nanomaterials" describes a class of nanostructured materials that, on a macroscopic scale, appear as voluminous bulk materials (polycrystals) composed of grains (crystallites) at the nanometer scale. According to other definitions, nanostructures or nanomaterials are forms of matter at the nanoscale, wherein at least one dimension falls within the nano-range. When describing nanostructures, it is necessary to distinguish them based on the number of dimensions at the nanoscale.Nanomaterials exhibit unique and pronounced characteristics compared to the same material without nano features. As a result, the physical and chemical properties of nanomaterials can differ significantly from their larger

counterparts or larger particles.Thus, the term "nanoscience" can be defined as the study of phenomena and manipulation of materials at the atomic, molecular, and macromolecular scale, where properties significantly deviate from those at larger scales. Nanoscience essentially involves the study and understanding of the properties of nanoparticles [3].

Nanosilver holds the highest degree of commercialization among all nanomaterials, and its application is largely based on its disinfectant properties. Examples of nanosilver applications include: Air disinfection - Bioaerosols are airborne particles of biological origin that can cause allergic reactions and have infectious and toxic properties. Their accumulation in significant quantities has been observed in indoor environments, especially in ventilation and air conditioning systems. External air pollution leads to the deposition of organic and inorganic materials on air ventilation filters, providing a suitable medium for microbial growth. The deposition of silver does not affect the physical properties of the filters, such as pressure drop and filtration efficiency, but significantly reduces adsorption efficiency and microbial growth [3].

Drinking water disinfection - Nanosilver has proven to be an effective disinfectant for contaminated water. It is produced chemically and uniformly applied to a porous ceramic material with a binding molecule called 3-aminopropyltriethoxysilane (APTES), creating a composite [3]. This composite can be stored for extended periods and is resistant to multiple rinses without losing nanosilver particles. Bonds are formed between the amino group (-NH2) of APTES molecules and silver atoms on the surface of nanosilver particles and the inner channels of the porous ceramic base, enabling a slow release of Ag+ ions that disinfect water contaminated with bacteria and viruses [4]. The impact of nanosilver particles on microorganisms is depicted in Figure 1.

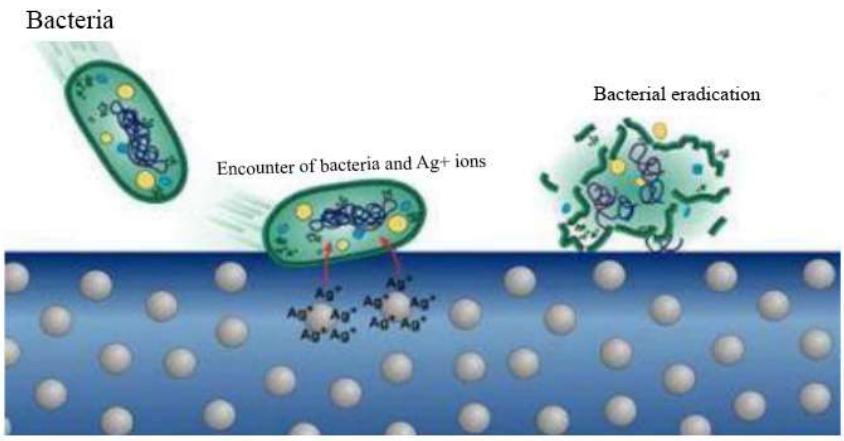

Figure 1. Presentation of nanosilver's effect on microorganisms [4].

Like gold, silver has been used for various purposes for thousands of years, including jewelry, tableware, coins, dental fillings, photography development, and explosive production (Chen and Schluesener, 2008). Due to its antibacterial properties, silver has been historically used for wound treatment and is still utilized today in water filters and disinfectants. In its colloidal form, i.e., as tiny particles dispersed in suspension, silver was once used to combat colds, and nowadays, it is an ingredient in dietary supplements used for allergic disorders (Wijnhoven et al., 2009) [5]. Humans have been using silver (Latin: argentum) for various purposes, one of which is its antibacterial action. Even Hippocrates noted the healing properties of silver, and during the Middle Ages, silver nitrate (Latin: lapis infernalis) was used to treat various inflammatory processes and as a means to remove warts. Before the advent of antibiotics, colloidal silver was used in the early 20th century as an antibacterial agent in various preparations (oral solutions, creams, etc.) and even to prevent gonococcal eye infection in newborns [6]. With an increasing number of bacteria becoming resistant to antibiotics, there is a constant search for

new therapeutic possibilities. The emergence of multi-resistant bacteria resistant to different groups of antibiotics poses a particular challenge. Thus, non-traditional antimicrobial agents like nanoAg are of particular interest [7]. Despite the proven bactericidal, fungicidal, and virustatic effects of nanoAg, the mechanism by which these actions are achieved is not fully understood. It is believed that the release of Ag+ ions forms the basis of the bactericidal action, as they react with proteins on the bacterial cell membrane, inhibit the respiratory process, induce oxidative stress, and hinder bacterial replication [8]. The effectiveness of nanoAg in combination with existing antibiotics is also under investigation, as well as whether the use of surfactants and anionic detergents on the surface of nanoAg can enhance its microbicidal activity [7]. Unfortunately, resistance has also been observed with nanoAg, for example, in one strain of E. coli [9].

An ideal antimicrobial agent should have maximum biocidal efficacy with minimal toxicity to humans and the environment. Further research is needed to identify the key physicochemical properties of nanoAg that will give it the characteristics of an ideal antimicrobial agent [8]. Upon contact with the cell membrane, nanoAg can interact with various membrane receptors and activate some of the signaling pathways within the cell. It can also cause membrane damage, leading to a rapid increase in calcium concentration within the cell and subsequent activation of apoptotic signaling pathways [10]. After entering the cell, nanoAg commonly induces oxidative stress, which is facilitated by the release of Ag+ ions during the degradation and dissolution of nanoAg in a biological medium [11]. Reactive oxygen species (ROS) that are produced are eliminated through cellular antioxidative mechanisms. When their capacities are overwhelmed, ROS cause protein denaturation, DNA damage, lipid peroxidation, and trigger an inflammatory response (Figure 2). Damaging the mitochondria leads to the generation of even more ROS, the formation of pores in mitochondrial membranes, disruption of the proton gradient, cessation of ATP synthesis, and collapse of the mitochondrial membrane potential, which is also the key signal for apoptosis initiation [13]. The internal apoptotic signaling pathway (via mitochondria) is precisely the main mechanism of cytotoxicity for metal nanoparticles such as nanoAg [12].

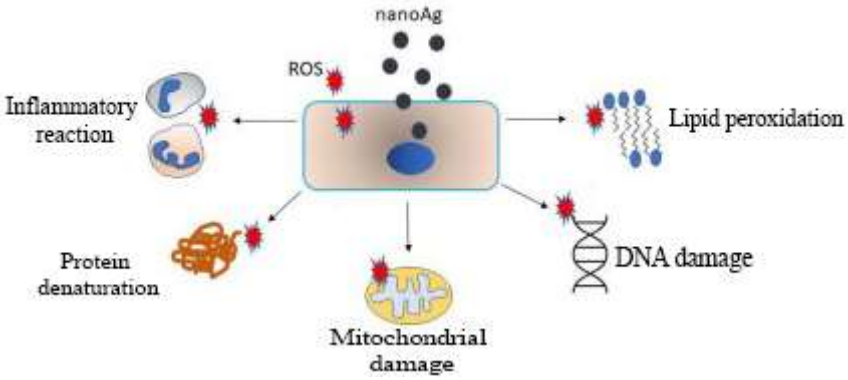

Figure 2. Oxidative stress and consequential changes induced by silver nanoparticles (nanoAg). ROS - Reactive Oxygen Species [13]

Silver nanoparticles can be obtained by two main methods. The "Top to Bottom" method involves mechanically grinding the material and stabilizing the resulting nanoparticles by adding a stabilizing agent, while the "Bottom to Up" method includes metal reduction [14].

The most commonly used method is chemical reduction. Reducing agents used during chemical methods include borohydride, citrate, ascorbate, and elemental hydrogen. Silver particles obtained in aqueous solutions have a diameter of a few nanometers. Initially, the reduction of various complexes with silver ions leads to the formation of silver atoms, followed by agglomeration into oligomeric clusters, which ultimately form silver colloidal particles. Control of chemical reduction is performed in two steps. First, a strong reducing agent is used to obtain smaller particles, which are then enlarged to approximately 20-45 nm in size in the second reduction step using a weaker reducing agent. To prevent

colloid clustering, chemical reduction is conducted in the presence of stabilizers [15]. More recently, the biosynthesis of nanoparticles has emerged as a distinct branch in the development of nanotechnology, where microorganisms, plant biomass, or extracts are being considered as alternatives to chemical and physical methods. In these processes, the need for high temperatures, pressure, energy, and toxic elements is eliminated, and advantages such as significant cost savings are highlighted [16].

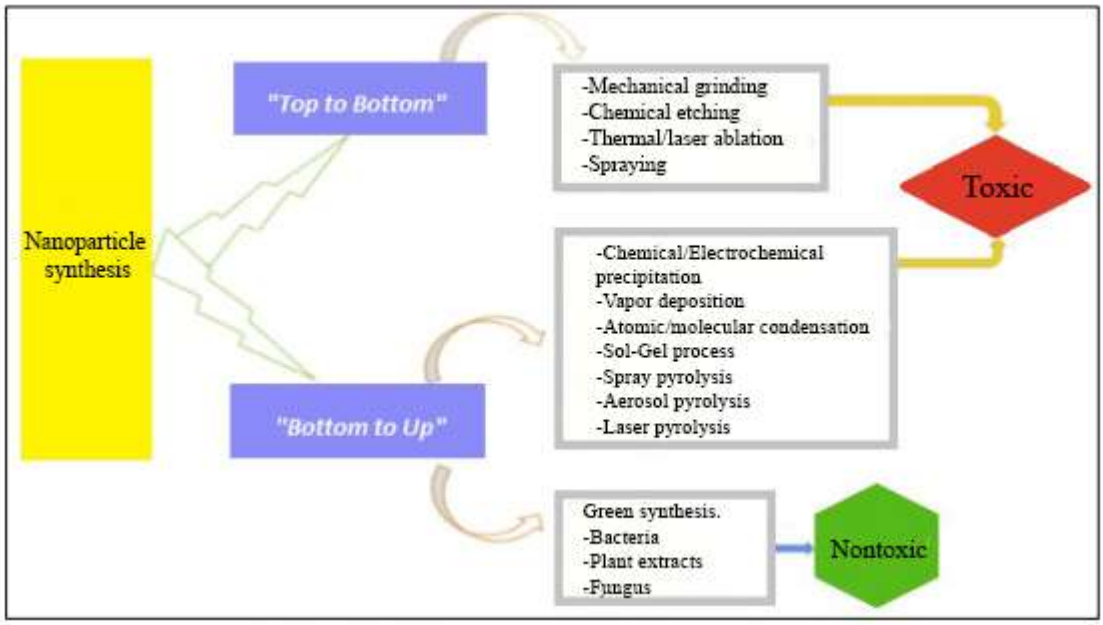

Figure 3. Different approaches to nanoparticle synthesis [16]

3. Effect of silver ions

Silver ions have a beneficial effect on a wide range of health issues as they inhibit the respiratory enzymes of pathogenic microorganism cells. Silver ions act as catalysts, blocking specific enzymes that bacteria, viruses, and fungi use in their metabolism, causing these disease-causing agents to be deprived of oxygen and nutrients, leading to their disintegration. Subsequently, the body eliminates them through the excretory organs' system. This process occurs so rapidly and efficiently that the microorganism does not have time to mutate or develop resistance. At the same time, our tissue cells remain unaffected because the process and mechanism by which they obtain oxygen are different from those used by microbes for the same process. In the mid-1990s, numerous experiments with silver ions were conducted, revealing that they do not affect acidophilus, the "good bacteria" found in the stomach and necessary for the body's healthy functioning [17].

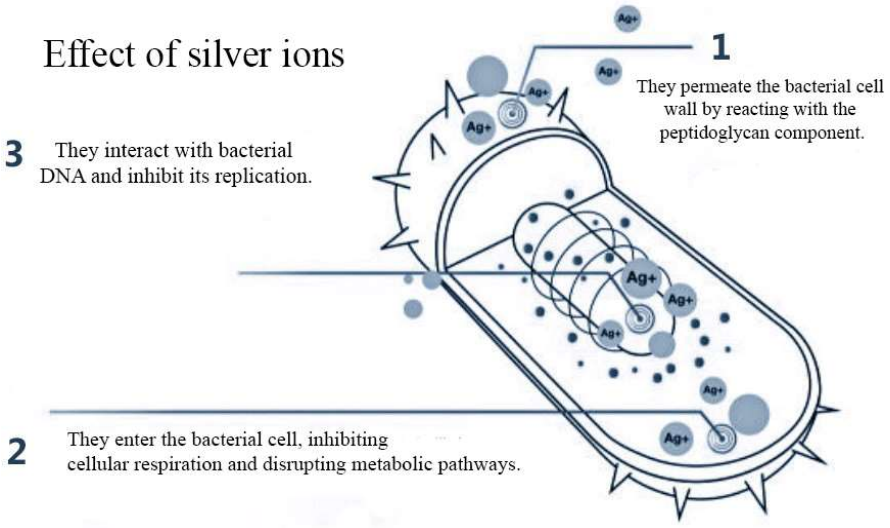

Figure 4. Effects of nano silver [17] .

3.1. Biocides on silver nanoparticles

A preparation based on silver nanoparticles and micro-particles with a concentration of up to 60 PPM suspended in water, intended for professional and daily use.In addition to absolutely pure water enriched with silver ions, the product consists of:

- Hydrogen peroxide - H2O2
- Absolute alcohol
- 0.1% peppermint oil used for respiratory tract inhalation, registered as an auxiliary inhalation agent in the Ministry of Health.

Effectively and durably eliminates all microbes, including bacteria, fungi, and viruses, as confirmed by certificates. Proven to be effective against SARS-CoV-2 (COVID-19) [17].

Figure 5. Preparation based on silver nanoparticles and micro-particles [17].

3.2. Effect of nano silver on wound

Silver nanoparticles are synthesized within a network of peptide fibers using ultraviolet radiation, which inhibits the growth of microorganisms such as E. coli, P. aeruginosa, and S. aureus.Hydrogen-enriched AgNPs on HDFa cells did not show significant effects on cell viability. The "AgNPs hydrogel" obtained from the extract of "Arnebia nobilis" root, tested on animal models to investigate its effects on wound

healing, yielded positive results due to its antimicrobial potential and provided new directions for wound treatment in clinical observations. The action of nano silver on the wound is depicted in Figure 6.

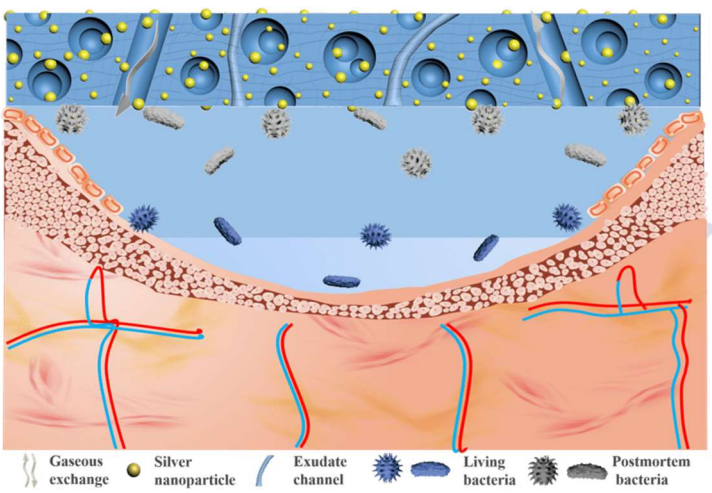

Figure 6. Illustration of the action of nano silver on the wound [18].

4. Example

NANO AG+ is added with silver during the spinning process to achieve a permanent antibacterial and deodorizing function. Additionally, the fiber cross-section is modified to enhance water absorption and rapid drying capabilities [19].

Figure 7. Socks impregnated with nano silver [19].

5. Conclusion

Thanks to its remarkable antibacterial properties and proven antimicrobial effects on wounds, nano silver demonstrates how essential nanotechnology is in today's time, especially in medicine, where it can be used in various areas depending on the purpose. For example, impregnating cotton gloves, masks, sheets, and linens with silver nanoparticles can protect individuals from various bacteria, microorganisms, fungi, and even COVID-19. Besides all the demonstrated and proven properties, I believe that much more investment should be made in nanotechnology because it is the future not only in the field of medicine but also in many other scientific disciplines.

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The influence of anthropometric research on the fit of clothing

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Abstract. The paper presents the influence of anthropometric research on the production of clothing with the aim of adapting to the shape of the body. Numerous factors change the shape and dimensions of the human body throughout life, which directly affects the design of clothing. The shape of the body and the relationship between the dimensions of different parts of the body in different population groups are studied using anthropometric methods. The results show that there are differences in individual body measurements within a given population group, as well as differences between younger and older people. The results of the anthropometric studies, which are also design parameters (body height and chest circumference) and form the basis for the design of the garment, are presented in the paper.

1. Introduction

With the development of human society, clothing also changed, its role was no longer just to protect and cover the body, but over time, more and more demands were made to meet new needs and interests. Clothing increasingly influenced the visual correction of body measurements, highlighting certain assets or concealing body defects. Over time, clothing reflected the social status of the individual. Increasing demands, whether aesthetic or functional, bring artistic and scientific knowledge and regularities to the production of garments. Today's clothing production is characterised by the mutual influence of science and art, which opens up completely new possibilities for the development of clothing design.

Systematic consideration of the issue of clothing fit involves the study of a number of elements and factors, especially those based on anthropometric knowledge, since the laws of clothing construction are based on body measurements and proportions [1]. Under the influence of numerous factors in human life, body shapes and body measurements are constantly changing. These changes directly affect the design of clothing and place high demands on its adaptation.

2. Characteristics and differences in the structure and shape of the female and male body

Certain physical differences between the female and male bodies manifest themselves in the internal structure (structure of the skeleton, muscles, organs) as well as in the external form of the body and are divided into primary and secondary characteristics. The primary features are due to the action of sex hormones of women and men, and the secondary features are due to the peculiarities of their body structure [2]. The female body has a smaller shape, less muscles, more fatty tissue and thinner bones. In terms of body structure, women have narrower shoulders and chest, but wider pelvis. Subcutaneous fat tissue deposits make the skin soft and round. The accumulation of adipose tissue in the female body covers the breasts, hips, thighs and waist and affects the shape of the body depending on the arrangement. The male body has a larger physique, more developed musculature, and less adipose tissue. He has wider bones, broader shoulders, and a narrower pelvis. A lower percentage of adipose tissue leads to a more plastic expression of muscles [3].

Adipose tissue is distributed differently in the body of men and women, largely determined by genes and to a lesser extent acquired.

There are different types:

- 1st type - tendency to accumulation of adipose tissue in the upper part of the body - shoulder girdle, chest and upper arms.
- 2nd type - accumulation of fatty tissue in the lower part of the body, where it includes the hips and thighs.
- 3rd type - accumulation of adipose tissue in the trunk area, encompassing the entire trunk, excluding the upper and lower extremities.
- 4th type - accumulation of adipose tissue in the area of the extremities, excluding the trunk.

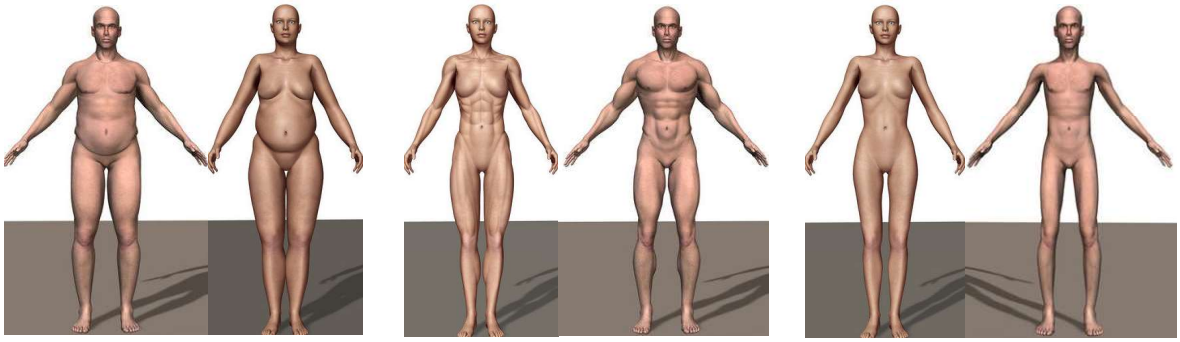
The next distribution is by age, so for women of mature age the accumulation of fatty tissue in the area of the hips and thighs or in the area of the chest and waist is characteristic. Men gain more and more fatty tissue with age, which accumulates mainly in the abdominal area. In older people, fatty tissue accumulates in the trunk area, with constant growth characteristic in the abdominal area and a decrease in fatty tissue in the extremities.

The thickness and distribution of adipose tissue in the body changes the external shape and affects the design of the garment. The most important factor on which the storage of adipose tissue depends is diet. In the so-called normal body, food intake and energy consumption of all organs are in balance, in contrast to a body that tends to increase fat storage. The reason for this may vary, and the problem may be a metabolic disorder, when the food introduced into the body causes abnormal fat storage due to organic disorders.

Also, there may be an unequal distribution of energy intake and consumption, when more food is taken in than energy is consumed. In both cases, there is increased formation of fat, which is either distributed throughout the body or deposited in specific locations. Fatty tissue is not equally thick in all parts of the body. Some areas of the face, hands, and feet have relatively little adipose tissue, while other parts of the body are zones of greater fat accumulation, depending on gender [3]. In men, the abdominal area represents a zone of greater fat deposits, while in women such zones can be found in the breasts, hips and thighs, in addition to the abdominal area.

The basic classification of the female body shape is as follows: Apple or circle, cylinder or rectangle, pear or triangle and hourglass shape. The distribution of adipose tissue, the main factor in changing body shape, is related to age, dietary habits, physical activity and hormone levels. The aging process inevitably affects body shape, and female sex hormones affect fat deposits and their distribution in the body. Namely, as we age and estrogen production decreases, fat tissue shifts from the buttocks and hips to the waist area, changing the previous body shape [4, 5].

The shape of the human body is also determined by the constitutional type (Figure 1). The most common constitution type is a mixed constitution created by genetic inheritance, in which the characteristic features of one of the three basic constitutions predominate.



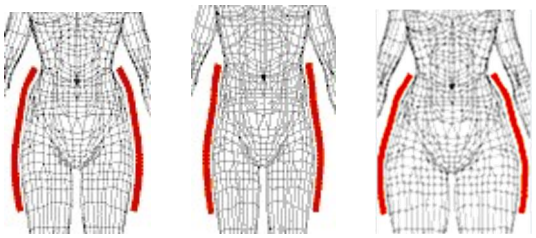
a) b) c)

Figure 1. William H. Sheldon's constitutional types: a) endomorphic, b) mesomorphic and c) ectomorphic type [4].

Posture is also an important factor that contributes to the overall shape of the body and, like body constitution, can change from one shape to another. The upright posture of the body is determined by the musculature, the symmetrical division of the body, the knee joints and the upright posture of the boot and head. It ensures balance when standing and walking. Posture is divided into: upright, normal and flexed posture.

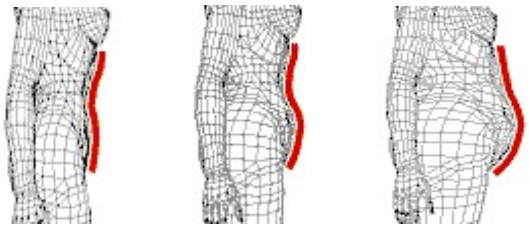
The determination of posture is made possible by proportion measurements and is of great importance for the cutting of clothing. Previous research has shown that about 50% of people have normal posture, 40% are upright or bent, and 10% have more pronounced upright or bent posture with the possibility of deformity [6].

In addition to posture, which determines body size, it is also important to consider the shapes that determine the hips, waist, and buttocks (Figure 2, 3, 4). All three of the above positions of the body affect its shape as a whole and thus the construction of the clothing that covers it.



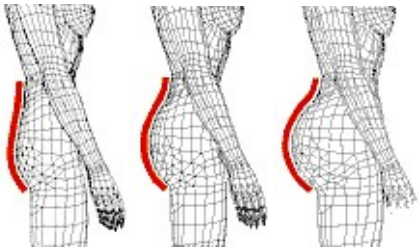
a) b) c)

Figure 2. Shapes of hips: a) normal, b) narrow and c) wide [4].



a) b) c)

Figure 3. Abdominal shape: a) normal, b) rounded and c) very rounded [4].



a) b) c)

Figure 4. Buttock shape: a) flat, b) normal and c) strongly accentuated [4].

The shapes of the hips, abdomen and buttocks shown make up the final shape of the body, which is due to the accumulation of fatty tissue in the areas mentioned.

3. Investigation of body measurements using an anthropometric approach

The anthropometric approach to the study of body measurements was favored by the knowledge of the variability of the proportions of the human body. By systematically performing anthropometric measurements on appropriate subject samples, data are collected on a large number of body measurements, leading to the determination of body shape. [1, 7]

At the end of the 19th century, anthropometric methods were used in medicine to determine the constitutional types of the human body. This involved determining the changes in body constitution throughout a person's life: in childhood, adulthood, and old age. Rapid changes in body shape characterize childhood, and after the age of 20, when development is complete, a constitutional type is formed (and maintained longer). Further changes occur in old age when the skeleton of the human body changes. The regularity of the mutual relationship of individual body measurements is determined by proportions, as well as the deviation of the body structure from the average structure and the determination of the presence of body deformations, which are important for the production of clothing cuts [1].

The development of human body typing and determination of constitutional types and their measurement, statistical processing of data and determination of the relationship between them stimulated a series of scientific researches that led to the development of modern anthropometric measurements of individuals of different population groups of the developed countries of the world in the 20th century. Anthropometry is important for the study of evolutionary changes in body measurements and proportions in population groups whose ancestors lived in different environmental conditions. Anthropometric data are also used in the study of changes in body size and shape related to the life cycle, evolution, questions of the relative contribution of genetic and environmental factors, body morphology under different living conditions, the relationship between body morphology and physical abilities and diseases, etc. [1, 9].

Anthropometric studies of the body measurements of indigenous peoples around the world have shown that their extremities (arm and leg length) tend to be larger relative to their overall body size. The aforementioned studies refer to the inhabitants of warmer regions and are explained by the body's adaptation to climatic conditions in order to maintain the body's thermal balance. Such adaptations indicate genetic changes that occur over generations. Ethnic differences in proportions were presented in the 1975 paper International Anthropometric Variability and its Effect on Aircraft Cockpit Design. Pygmies from central Africa are the shortest people in the world, according to some records, and the tallest people are from the northern Nilotes of southern Sudan.

The main height of the first group is 143.8 cm, and that of the second group is 182.9 cm. Thus, the span of the main heights is 39.1 cm. The smallest Pygmy was just under 130 cm tall, and the largest Sudanese was 210 cm tall (i.e., 162% taller than the smallest). The large breeds of the industrialized countries belong to the generally colder countries of the Northern Hemisphere: Scandinavia, Holland, Great Britain, Belgium, Germany, and France. The populations of Portugal, Spain, Italy, Greece, and Turkey are always smaller on average, which may indicate the influence of climate on body growth.

The peoples of Japan, Thailand, Vietnam, and Korea are significantly smaller due to shorter leg lengths. Japanese and other Asians have proportionally the same sitting height as whites but shorter legs, while blacks have been shown to have longer legs relative to their trunk than whites. Differences in torso circumference also suggest that the average Asian, for example, is narrower in the chest area than a white of the same size. An Australian aborigine has a slimmer build than his white compatriot of the same height [1]. Since World War II, according to statistical data, Americans were the tallest people in the world, but this began to change after 1955, when Europeans grew an average of two centimeters, and some Asian peoples grew even more [10].

According to research data published in the scientific journal Annals of Human Biology, the Dutch are the tallest people in the world and not like Americans, who were taller by almost five centimeters, while Dutch women were taller than American women by 5.7 centimeters. It is believed that the reason for this is the better health care and diet of Europeans. Research shows that there are significant differences between the most represented human races in the rate of growth and development, as well as in final height and build, and that it is more difficult to separate the influence of inherited factors from

environmental factors (climatic conditions, diet, etc.). The large influence of environmental factors is confirmed by observation of the effects of migration on body growth, and previous assumptions about the dominant genetic factors of growth are changing [4, 11].

4. The importance of anthropometric research for clothing construction

As society changed, awareness developed of the need for clothing to best fit the shape of the body. Clothing should not only protect the body, but also be comfortable and meet the high esthetic standards of a particular era. All this points to the need to accurately measure the body of a large number of people, so that by determining the body measurements, a wealth of sizes and shapes of clothing could be created. It is with this goal in mind that the anthropometric measurements of the population are made.

A garment designed for a specific type of consumer or group of consumers with a recognizable body structure is based on the production of high quality and accurate clothing. The cut of a particular garment must be constructed according to the measurements obtained on the body in accordance with the constitution of the body. The methods of constructing clothes are based on the main body measurements. The main body measurements are the most important measurements of the female and male body and are used for making clothes. Their values and proportion ratios enable the calculation of construction dimensions with the aim of constructing a specific garment. For the industrial production of clothing, a system of clothing sizes was established based on the main body measurements, where height and chest circumference are the primary main body measurements [1, 6, 12].

With the aim of monitoring the changes in body measurements in order to improve the fit of clothing, anthropometric measurements were performed on the population of the Republic of Croatia. The average values of numerous body measurements were obtained by statistical data processing. The obtained average values of body height and chest circumference of adult women and men are shown graphically in Figure 4 and 5, respectively, and the values are listed in Table 1 and 2. The change of both body measurements under the influence of aging of the organism, i.e. depending on age, can be clearly observed among the respondents.

Table 1. Average values of body height and chest circumference for men by age.

Age	-29	30-39	40-49	50-59	60-69	70-79	80-85
Body height (cm)	179,4	178,7	176,9	175,5	172,7	171,3	169,8
Chest girth (cm)	95,7	102,1	104,5	106,1	105,5	104,9	104,9

Table 2. Average values of body height and breast circumference for women by age.

Age	-29	30-39	40-49	50-59	60-69	70-79	80-85
Body height(cm)	166,7	165,6	164,2	162,8	160,7	158,2	157,5
Chest girth (cm)	90,3	94,1	98,5	103,2	105,6	105,3	104,1

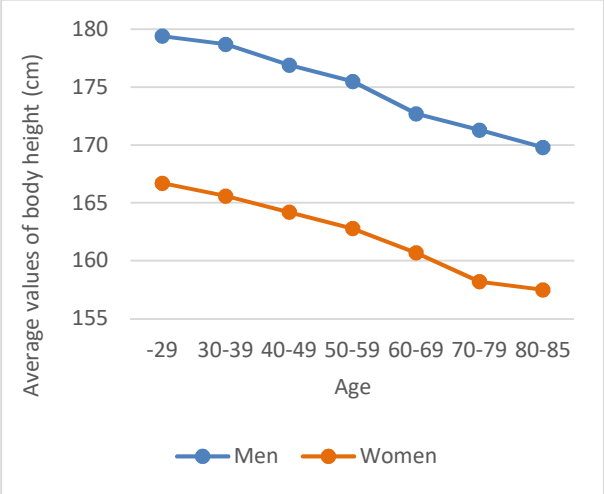


Figure 4. Mean body height of men and women by age groups.

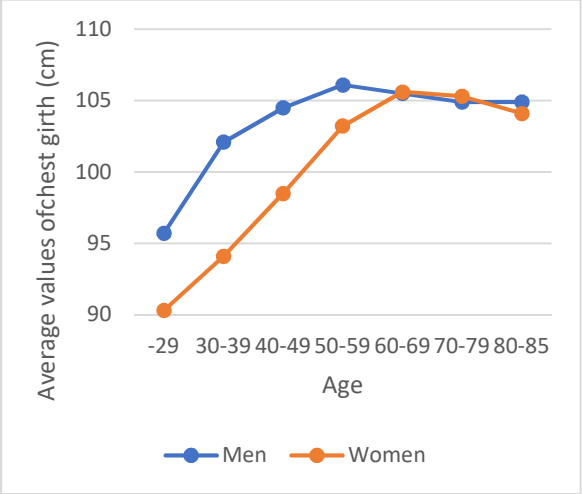


Figure 5. Mean chest girth of men and women by age groups.

The results presented confirm the importance of anthropometric research for improving the fit of garments

5. Conclusion

In order to improve the methods of making clothes, it was necessary to know the structure of the human body. This stimulated research into body shapes, the knowledge of which was applied to the construction of clothing. Over time, construction methods became more complex. Some laws have survived to this day, but the changes in the human body show that they need to be further improved. Earlier research on the shape of the human body indicates changes caused by the action of various factors, which are adopted over time by a growing number of people with similar lifestyles and the same climate. However, the construction of garments according to the previous laws of body proportions leads to an inappropriate fit of such a garment. The solution to this problem is achieved by anthropometric measurement of a certain population group and knowledge of their current physical characteristics. The new measurements and the laws about their mutual relationship contribute to the development of construction methods and, at the same time, to a better fit of clothes.

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Migration and clothing: a piece of home on the road – the resurgence of traditional clothing in modern fashion industry

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Abstract: The term migration, represents the common understanding of a person who moves away from their usual place of residence, either within a country or across an international border, temporarily or permanently, and for various reasons, as defined by the IOM organization. With Bosnia and Herzegovina facing a migration crisis within its borders, and the migration rate constantly rising over the last two decades due to the political and the economic state of the country, many people have found themselves integrating into different, mostly Western and Central European cultures. Many such immigrants from third-world countries carry a piece of their "homeland" and culture with them, even though they have left their country of birth to live in a more economically stable land. Be it due to nostalgia or love for their own culture and people, the most noticeable items carried are their traditional clothing and jewelry. Be it the sari dresses of Indian women, or the gele headscarves of the Nigerians, these garments are seen on people even after they have moved to a different continent and have already integrated into the societies of their new homes. These pieces of clothing have also been modernized for easier use in their everyday lives, which Bosnian traditional garments have yet to experience. In this research paper, the main theme is tied to the history of northern-Bosnian traditional clothes, primary patterns present in their designs, as well as how such clothing could be introduced to a modern-day market. This paper focuses on reimagining that clothing through a modern design perspective, making designs specifically to celebrate traditional Bosnian garments, designed for everyday use, in the form of a fall/winter collection.

1. Introduction

Garments have for a several millennia now stopped being just a means of keeping a humans body warm and safe from natures dangers, they have instead become an integral part of one's identity, a way to show status, flaunt wealth, or simply express ones ethnical background. Traditional clothing is used to express ones national identity connected to their geographical place of birth or ancestry, often times a show of that ethnic's history, and has been preserved in many cultures to this day. While mostly reserved for special occasions in the 21st century, there has been a noticeable rise in its incorporation in fashion trends of today – with the rise of constant migrations occurring around the world, it's harder in this globalist sphere to carry a piece of one's home and identity with themselves. While mostly seen in the forms of jewelry and accessories, traditional costumes in their full scope are becoming essential for immigrants who move far away from home to find a new and financially more stable life in the west, as a means of not feeling fully like a stranger in a strangers land and in hopes to build communities of

similar backgrounds as well to keep their traditions alive. By doing so, the clothing is being preserved and modernized in today's everyday capitalistic world where people oftentimes feel as their clothes make them uniformed and disconnected from their heritage. Bosnia and Herzegovina is no stranger to traditional wear, who's clothes aesthetics and features are not only a show of its history of different influences from many empires that ruled this nation, but also a unique approach to traditional Slavic clothing. The main purpose of this research is to see how these garments that are very much underutilized in the modern setting, could be incorporated into the fashion trends of today, while also doing a deeper scope into the history of northern Bosnian traditional clothing.

2. Migrations and diaspora culture

While migrations can represent many different things, based on how temporary they are and what are its causes, it's mostly defined as a permanent change of residence of an individual or a group. [1] Internal migration is a type of migration focused on movement of either individuals or families from one area to another, be it from rural areas to cities or vice versa, while international migration presents permanent change of ones country of residence. Secondly, migration can be voluntary or forced, with most voluntary being undertaken for hopes of better economic opportunities, housing, or other personal reasons. Forced migration involves people who have been displaced due to war or other political reasons by government, those who have been forcibly transported as prisoners, or those who have been sold into slavery and as such shipped from their homelands. [1]

When it comes to voluntary migration, there are factors that motivate people to leave their homeland for a different country, such as political, social and economic influences, better known as push and pull factors. Migration is oftentimes a means of securing a better and stable life for many people from third-world countries that suffer from lack of quality housing, low minimal wages and unfairly paid labor as well as lack thereof, political corruption or social prejudice, all of which significantly lower their quality of life, making them more often than not desperate to leave their original place of residence. Other than that, rising temperatures and inhabitable lands have proved to be a viable reason as to why so many people choose immigration as a way to search for a better life. Due to rapid climate change, those living in rural places and living off of agriculture have witnessed their crops either die or not bear enough fruit to bring income, therefore moving to more suitable areas for such businesses. [2] Those factors are considered push factors as they determine a motive to leave one's country of origin and start new life in a foreign land. Many such instances have to do with overall economic migration that has been very noticeable since the 19th century and the industrial revolution as it is shown by ever-rising emigration in the West. By offering more stable jobs, a more liberal political sphere and a promise of stability, these countries have what's considered pull factors that motivate a person and encourages them to immigrate to a particular country. That trend of immigrating for mostly economic and political reasons has been noticed and encouraged by countries that have low birth rates in the west, by offering scholarships in certain research fields, promises of stable job and better workplace in exchange for gaining new tax-paying citizen and ensuring that the country stays economically prosperous. [3]

Diaspora is a population that has moved from their place of origin and has, in that process, scattered across regions worldwide. There are different types of diaspora found in the world and different kinds based on their causes, such as labor immigrants or historical colonialism. These communities oftentimes maintain their culture, traditions and beliefs from their homeland, as well as keeping in touch with people from their ancestral land, as well as a lack of full integration into their new place of residence, by building their own neighborhoods where they are freer to express their ethnical identity or speak in their mother tongue. Even if diaspora communities tend to stick close together, diaspora populations are always going to be highly outnumbered in their new country of residence. [4] Such communities have a big influence on their host countries relationships and policy making relation to their homeland, phenomenon known as diaspora management, a set of policies forged to help with the incorporation and integration of these communities as well as building links with their own diaspora that traveled abroad. Diaspora as a term is tightly connected to a sense of displacement, because such communities usually have a strong wish or desire to return to their homelands again, due to being separated from their nation

because of political, or in most cases, economical reasons. It's also important to note that many historical instances of diaspora movements have been traumatic ones – African slavery, centuries of Jewish displacement, the Irish famine, as well as diaspora from the Middle East that are fleeing due to conflict. [5] These diaspora populations had no other choice but to move, which is why in modern times, these communities tend to focus on their homelands culture through objects, beliefs and clothing pieces, through which they keep their cultural memory alive no matter where they live. Cultural memory represents a form of collective memory shared by an ethnic group of people, in forms of objects known as cultural symbols, through which people can connect through their shared experiences as well as celebrate their identity and history, by also providing understanding of values and beliefs of the past. It is a way to find a sense of belonging by sharing identities and reflecting on growth through past historical trauma connected to a nation. [6]

Figure 1. Italian immigrants arriving in New York due to poverty experienced at home.

Since the Bosnian war in the 90s, Bosnia and Herzegovina has been seeing a rapid decline in population, according to the data of the 2022 UN report titled "World Population Outlook", where Bosnia and Herzegovina ranked highest by suffering the immigration of over 1.5 % of its population annually, while also noted as the country of the "lowest low" fertility rate of 1.25% in the world. [7] It is estimated that due statewide corruption, lack of working places as well as gender inequality, Bosnia and Herzegovina might face up to a 50% reduction of its whole population by 2070, while the democratic structure of those still living in this country will be mostly composed of older and retired population. [7]

3. Traditional Bosnian clothing

Bosnia and Herzegovina is not a stranger to a variety of traditional garments found throughout the land. Inspired by many nations, cultural exchanges and the ever-changing cultural climate of the region, Bosnian traditional clothing contains elements of Slavic, Mediterranean and oriental ornaments and cultures, as well as western influences from the 19th century onwards. Different regions bore different primary elements, but even in these differences, Bosnian traditional wear has had a distinct feeling to it. What is of particular importance in the development of folk costumes, when it comes to new cultural influences, is the new terminology that comes with new materials and new cuts in costumes. In addition

to the preserved old Slavic and to a lesser extent Romani names, oriental terminology for many parts of costumes is very widespread, such as: zubun, ječerma, fermen, žemadan, koparan, bošča, fez, etc. [8] The oldest instances of recorded Bosnian and Herzegovinian clothing could be found in the old Illyrian tombs near Glasinac, where in some graves metal ornaments that covered the torso were discovered, as well as ancient cloth that was used for their garments.

Wool had the greatest use in traditional garment making. It was used to make long textile decorations, both unrolled and rolled, as well as for coats, and summer and winter clothing as well. In addition, it was used for socks, aprons, fabrics and bags. The colors of such garments were usually white, black and dark blue, with such clothing used by all ethnic groups in Bosnia. Leather was used most often in its unprocessed, only dried "raw state". Footwear was made from such materials, i.e. opanci, which were also called putravci, oputnjaci, or fašnjaci. The shoelaces used to knit these boots were made out of thin sheep or goat skin strips. In addition to these shoes, special boots were made from sheep leather, and they were worn by wealthier young people at the end of the 19th century. This phenomenon was actually related to the ever-growing influences of Austria-Hungarian fashion trends of the time. The poorer people benefited from these influences as well, as they started wearing sandals made out of sheep leather, which were cheaper than the shoes found on the market. Opanci from that leather were made mostly worn in Sarajevo, Visoko, Travnik, Jajce, Banja Luka, Bugojno, Tuzla, Brčko, and Bijeljina. Sarajevo opanci, also known as Saraj shoes, and the ones made in Visoca, had their own special style and were differed from the "white opanak" shoes from Brčko. [9]

Figure 2. Late 19th century western Krajina clothing.

Posavina costumes have their own unique characteristics. The women's costumes of the Serbian and Croatian population were composed of a shirt and pants combination. The shirt, also known as "aljina", is made of cotton, cut at the waist and richly pleated at the back of the waist and around the neck. The sleeves were cut obliquely around the shoulders, long and wide. "Aljine" were ornamented with floral motifs along the sleeves and the back of the skirt. The pants were the same as in Central Bosnian traditional garments. Zubun, was an upper coat worn by people from the rural areas on the western side of the Bosna River, made of black cloth, decorated with red leather or woolen strings. They also came with fur coats, as well as multi-colored leather appliqués. The winter top dress was hip-lenght, long sleeved, and typically made out of black cotton cloth or dark colored "Bulgarian" wool cloth. Posavina

women's aprons have one specific feature. They are woven diagonally, "in four threads", with square or rectangular patterns, decorated with long fringes. The basic footwear of the area, also known as traveling shoes, were made of processed leather. The socks were knee-high, made of multi-colored wool, featuring floral motifs, as well as being decorated with white beads. [10]
The basic footwear there were traveling woolen shoes, with shoes made of leather also being worn, together with long and heavy woolen socks reaching to ones knees. The socks are long, made of multi-colored wool, mostly knitted on five needles, with floral motifs. In men's costumes from Posavina, the main characteristic is the shirt and linen pants also known as "gaće". The shirt was wide similarly to a women's one, pleated at the back and at the waist, and sometimes adorned around the neck, cut and richly pleated at the back, long enough to reach one's knees. Like women's shirts, they are highly decorated, but only around the sleeve area. Pants are long-legged, wide, and slightly narrower lower towards the calves, and are made of the same cloth as the shirt as well as decorated with lace around the edge. [10]

4. Designing of collection "Lower Ends"

Influenced by this research, collection "Lower Ends" (the first translated name of Bosanska Krajina to English), tackles the themes of homeland, culture and its traditional form. The main piece of said collection is a modern interpretation of the traditional northern-Bosnian shirt silhouette, its embroidery and the traditional apron worn by villagers as a means of keeping ones clothes clean from any type of dirt that might occur during the day, as well as to help carry certain things, be it by folding or with first versions of what we today know as pockets. These items are presented in a 21st century light, inspired by metropolitan streetwear. These original garments are presented in earthy tones usually found in traditional Bosnian costumes.

Figure 3. Fashion illustration of the created garment.

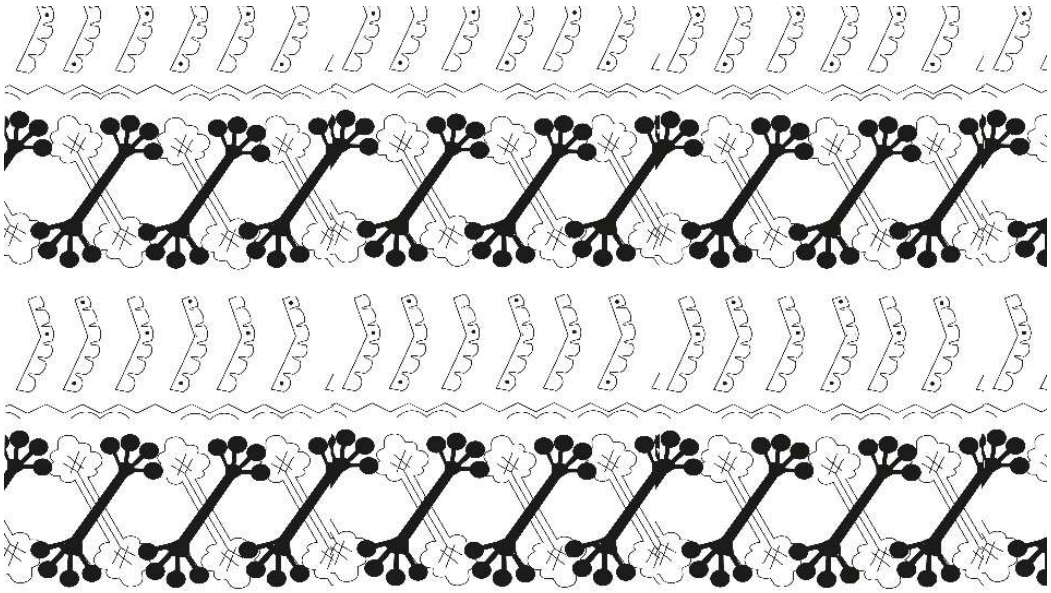

Figure 4. The featured print.

4.1. The shirt

Based on both rural men's shirts of 18th and 19th and women's "aljina" dress, the construction is simple with an exaggerated collar and sleeves to emphasize the simplistic a-form of the garment. The cuffs which traditionally feature embroidery, are ornamented with a geometrical floral print, design reminiscent of the ones usually seen in clothing of that time. [9] The shirt itself has no buttons nor visible stitching, making the garment comfortable and adaptable to many different body types, as shirts of that era was made to be passed down as many generations as possible, to ration on textile and make sure the clothing itself endures changes. Because of its function in mind, the shirt is made of a mixed cotton textile, so it fits for both hotter and colder weather, even though the collection itself is made for the fall/winter season.

4.2. The print

As mentioned before, the print is heavily inspired by embroideries found on garments from the northern Krajina area. The design of the ornaments is floral, yet geometrical, made to keep the cuffs and collars functional, able to stretch, while also carrying a certain aesthetic of its people. [9] As such, a modern and more accessible version of the ornament would be its print form, which is heavily features throughout the collection.

4.3. The apron

While construction-wise the apron is near-identical to its former counterpart, it also features two frontal cargo pockets which are decorated with the established print of this collection. In a sense, it can be used both as a bag and an apron, with an adjustable belt that can fit the hip area, connected to the apron itself with two metallic rings adorned by runes, as a nod to the traditional jewelry of northern Bosnia. The material of the apron is that of a puffer jacket – a heavy cotton stuffing and a nylon surface, which is inspired by modern trends of using durable and puffy materials as to add volume to the garment.

Figure 5. The creation.

5. Conclusion

As Bosnia and Herzegovina faces rapidly rising immigration rates, as well as many diaspora around the world finding ways to modernize their way of cultural dressing, this paper and collection tries to fulfill a sense of nostalgia many Bosnian immigrants carry with themselves in their new countries of residence. While it is true that traditional Bosnian clothing is still well known and preserved today, the clothing that's found in smaller regions of this country are very far and few, with Krajina clothing being one of those which we oftentimes overlook in our discussions about cultural garments of this nation. With its rich history, Krajina clothing has still a lot to offer to modern designers, something replicated in this collection. With all of this in mind, this collection was a way to honor a less talked about piece of history that might make someone feel more included in their own nation's culture, and spark joy at the memories of their homeland.

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Redefining Sustainability in High-Street Fashion: Integrating Zero-Waste Approach and Virtual Clothing Production

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Abstract. High-street fashion, defined as easily accessible clothing for public purchase, has become one of the main contributors to the accumulation of excessive fashion waste. While innovative and sustainable clothing production models and fashion waste management strategies are gaining strength in smaller production lines and fashion studios, high-street fashion shows minimal or negligible changes to its deeply rooted principles. In order to maintain competitiveness and meet the increasingly strict sustainability requirements advocated by global organizations, high-street fashion manufacturers are taking gradual but limited steps towards environmentally aware production, often resorting to marketing manipulations that undermine positive examples of sustainable practices. Using the virtual clothing production software program CLO, this paper presents a new approach that aligns with the dynamic demands of the fast-paced high-street fashion market, effectively addressing the temporal and logistical complexities inherent in the zero-waste approach. This research paper reveals a new paradigm of creating realistic virtual clothing visualizations, including prototype simulations that meet the discerning aesthetic preferences of environmentally (un)aware consumers and contributes to promoting an environmentally and economically sustainable future. Furthermore, it challenges prevailing understandings of high-street fashion with an alternative perspective that emphasizes the potential for sustainability beyond conventional stereotypes.

1. Introduction

The fashion industry faces some of the most crucial environmental challenges, producing clothes that consumers purchase out of desire rather than necessity [1]. The stimulation of production through a positive consumer response quickly led to the emergence of „fast fashion“. Clothing became diverse and accessible for public purchase on major city streets (known as „high-street fashion“) and/or online, where the highest turnover of goods and services occurs. According to available studies, fashion brands have widely adopted the „fast fashion“ business model as it can enhance competitiveness, reduce costs, and shorten production time [2]. Fashion brands, focused on profit, often disregard the environmental footprint [3] they leave behind. As public awareness of the fashion waste problem grows, pressure mounts on fashion brands to reconsider their business models in order to minimize resource exploitation and take responsibility for waste generation. Consequently, this paper considers a „zero-waste“ approach to minimize waste and, ultimately, extend the clothing lifecycle through innovative design and pattern-making with the aesthetics/preferences of high-street fashion consumers. The focus will be on eliminating fashion waste during the production process, considering the role of the design phase in communication with subsequent production phases.

The objectives of this work are manifold: (1) meet the preferences of „high-street fashion“ consumers; (2) investigate ways to shape the awareness of „high-street fashion“ consumers towards „greener habits“; (3) explore „zero-waste“ approach for clothing production that suits the preferences of „high-street fashion“ consumers, with multiple possibilities for redesign/reuse; (4) test the software program (creating virtual, true-to life clothing visualization) for fashion design, 2D pattern-making, marker/print layout, 3D simulation, and rendering capabilities to compensate „zero-waste“ approach time losses in production; and (5) consider the boundaries of zero-waste approach and conventional clothing production processes.

The result will be a zero-waste approach with purposefully designed pattern pieces without fabric remnants, offering functional and/or aesthetically alternative styles. Due to the versatility of high-street fashion clothing, a range of positive effects is expected: (1) increasing consumer inclination to consider the value of clothing in their purchasing decisions; (2) prolonging the clothing lifecycle; and (3) postponing the psychological obsolescence of clothing [4]. These considerations will pave the way for future research to intertwine design and pattern-making phases in establishing a flexible system with a zero-waste approach, rather than conventional production processes.

2. „High-street Fashion“ Role in Shaping Preferences of „Fast Fashion“ Consumers

The term „high-street fashion“ refers to the clothing that can be purchased in the shops on the main streets of the cities („high street“ or „main street“ is the street in the city where most shops are located), easily accessible and affordable for public purchase. High-street fashion is defined by trendy clothing that takes ideas from the catwalks or „celebrity world“ at a speed that meets consumer's demands. A perfect example is the fashion brand Zara, which is ready to dress „both him and her“ as characters from the movie Barbie, with Margot Robbie and Ryan Gosling in the lead roles, as early as July 17, 2023, before the movie premiere. These marketing ploys of the movie-inspired costume collection offer consumers the chance to be the perfect Barbie and Ken in real life. On the occasion of Barbie mania, which has been raging for a season, Zara opened two temporary Barbie stores in New York and Paris to mark the collection infused with iconic looks featured in the movie.

When Zara, which opened its first store in northern Spain in 1975, arrived in New York in the early 1990s, people heard the term „fast fashion“ for the first time. The New York Times, an American daily newspaper, invented the term to describe Zara's mission that clothing should take only 15 days to go from design to in-store sales. Zara also invented the concept of limited availability through purposefully smaller amounts of certain clothing designs that foster a sense of urgency among consumers, creating an environment where purchasing decisions are made quickly and impulsively [5]. The aim is to launch the latest trends into the market as quickly as possible so that consumers can quickly get certain clothing designs while they are still highly popular and then, unfortunately, dispose of them after a few wears.

3. Environmental Consequences of “Fast Fashion” in the Linear Economy Model

Purchase of clothing used to be an occasional event a few times a year when the seasons changed, the clothing was outgrown or worn out. The fashion industry was releasing only two seasons of clothing collections in a year. Purchase of clothing became a hobby for large masses of people when the production and marketing strategies focused on personal style to convey self-expression with the idea of „options for every consumer“. With lower prices of clothing in stores, due to an off-shore strategy that exploits cheap labor, fashion brands, with a positive response from consumers, began to encourage mass production [6]. This business model strategy capitalizes on low wages while avoiding basic worker rights and safety protocols. This constitutes a key factor in the toxic system of excessive production and consumption, which has brought the fashion industry to second place in terms of global environmental pollution, just behind the oil industry [7]. This system of production and consumption includes a wide and varied overview of clothing styles that overload the leading fashion brands with an extremely short time gap between the initial appearance of new trends on the catwalks and the subsequent market flooding with collections of cheap imitations, thus encouraging a „culture of waste“. The „culture of waste“ in this case is characterized by the mentality of consumers who encourage excessive purchase

and disposal of clothing. As a result, consumers don't perceive clothing as a long-term investment. The emphasis of the current clothing production model is on „quantity over quality". Clothing is disposed of as soon as it goes out of style or suffers minor damage, rather than being reused or redesigned. As a consequence, landfills and incinerators receive huge amounts of clothing. Solving the problem of the „culture of waste" requires a transition towards a sustainable business model.

The current „fast fashion" business model is based on a linear economy model [8]. The linear economy model, which is embodied by the value system „take-make-dispose", has been the driving force behind clothing production and consumption for a long time through the uncontrolled depletion of resources and the ubiquitous generation of waste. With a linear economy model, there is no real chance for effective adoption of sustainable principles. Sustainable principles development requires the involvement of all stakeholders: the textile industry needs to invest in clean technology, the fashion industry needs to come up with new business models, consumers need to change their purchase and disposal habits, and legislators need to change global business model rules.

4. Possibilities and Challenges of "Fast Fashion" Transition to the Circular Economy Model

Detaching from the „fast fashion" business model involves the strategic reduction of excessive production and consumption. Many, if not all, of these negative outcomes, could be mitigated by the transition to a circular economy model with certain challenges and possibilities. Establishing stable fashion brands focused on higher quality would ensure that sustainable practices are respected in every phase of production, from fabric sourcing to clothing distribution. Ultimately, the transition to the circular economy model requires collaboration and coordination among all relevant stakeholders to achieve real change. By collectively embracing their responsibilities, stakeholders can contribute to a fashion industry that promotes ethical production and consumption. In recent years, there has been significant pressure on government regulations to push fashion brands towards a change in approach or face consequences. European Union initiatives for „green taxation" could achieve environmental protection policy goals, encouraging a transition towards fashion industry sustainable strategies in resource and waste management and consumer „greener habits" [9].

The latest research papers address two resource and waste management strategies: proactive (prevention, reduction) and reactive (reduce, reuse, recycle) [10]. These strategies often necessitate investments in technology. These investments can incur upfront costs that, in turn, could influence the pricing of clothing. However, as these technologies become more mainstream and widespread, economies of scale might help mitigate initial price increases. While some consumers are willing to pay a premium for environmentally friendly clothing, others may be deterred by higher prices. The development of price structures that take into account the environmental impact of clothing can reshape consumer preferences to perceive clothing as valuable and enduring investments, reducing disposal frequency. Fashion marketing could help boost sales and profits of environmentally friendly clothes as well as build brand awareness and alter consumer preferences. This is precisely why the concept of „green marketing" is emerging and empowering consumers to make informed decisions when purchasing and disposing of clothing [9].

5. Circular Economy Model for Achieving Zero Waste Approach in Fashion

An alternative for the fashion industry towards reducing the environmental footprint is certainly a circular economy model or zero-waste approach, frequently intertwined or used interchangeably. Despite the similarities in rectifying the flaws of the linear economy model and eliminating waste, the differences can be explained by examining the principles of both concepts. While the zero-waste approach focuses on keeping waste out of the environment, the circular economy model goes further aiming to regenerate the environment. A more abstract way of thinking is to envision the zero-waste approach as the goal and the circular economy model as a plan to achieve it. The zero-waste approach is broader, with potentially multiple interpretations. In the context of the fashion industry, the zero-waste approach is a system where waste is eliminated in every phase of production: from fiber and yarn to

fabric, fashion design, pattern-making and cutting, sewing and finishing, storage, transport, and sale of clothing; to consumption: purchase and disposal of clothing [11].

Consideration of the zero-waste approach in this research paper represents fashion design as the most significant phase supporting the transition from sustainable design to design for sustainability. The term „zero-waste approach" refers to clothing designed and cut, leaving little to no fabric remnants, and enabling easy clothing redesign/reuse. While fashion designers cannot fully control what happens to the clothing in the hands of the consumers, they can determine to what extent clothing can be redesigned/reused, without using new fabric [12]. Fabrics require time and effort at various phases of production, from fiber extraction to yarn formation, fabric design, and weaving fabric making processes expensive in terms of resources and time.

6. Design and Virtual Clothing Production of High-Street Fashion Using Zero-Waste Approach

For fashion designers, eliminating waste should be the top priority considering global environmental pollution. If the fashion industry aims to adopt the highest and most efficient level of waste management, waste must be eliminated in the fashion design phase. This implies that designers must understand the clothing production processes involved in creating their designs. A critical step in the clothing production process, as it determines how efficiently and economically use fabric is marker which refers to a layout plan that indicates the arrangement of pattern pieces on a piece of fabric before cutting. The marker is typically created by a patternmaker or a computer-aided design (CAD) system/software program. It takes into consideration factors such as fabric width, pattern piece size, grainlines, and any pattern-matching requirements. The goal is to maximize fabric consumption, minimize fabric remnants, and ensure that pattern pieces are placed correctly on the fabric to maintain the desired fit and design of clothing. The amount of acceptable fabric remnants in the marker is approximately 15% of the total fabric and reducing fabric remnants is more desirable than reusing or recycling [13]. Fabric remnant should be tolerated at 0-5%. To address the challenges associated with fabric remnants, the innovative zero-waste approach challenged this norm designing patterns that maximize fabric consumption and eliminate fabric remnants in the realm of pattern-making which involves markers that use the entire fabric piece [14]. These remnants are typically leftover scraps or pieces of fabric that are too small to be used in the conventional clothing production process.

A brief consideration of possible reasons for the fabric remnant in the marker reveals that clothing with a specific design is immutable, as each subsequent phase conforms to achieving specific aesthetics. It takes time for consumers to develop new aesthetic preferences. Encouraging consumers to embrace zero-waste approach aesthetics requires a transition in their perceptions and openness to alternative styles. This approach recognizes that sudden and drastic changes in high-street fashion aesthetics can be met with resistance from consumers. High-street fashion consumers might gradually incorporate a zero-waste approach aesthetic as they experiment with their style. They are more likely to adopt a new style when they see people they admire or respect adopting a new style, it can alleviate doubts and hesitations. Celebrities and influencers can play a crucial role in portraying the style as not just sustainable but desirable. Genuine endorsements from celebrities and influencers who are personally passionate about sustainability can leverage their influence to raise awareness about the environmental impact of conventional clothing production and innovative zero-waste approach. This increases the chances of reaching a broader consumer base. Also, fashion brands can experiment with different combinations of these conventional and innovative designs, leading to a diverse product range that caters to various consumer aesthetic preferences. By offering both, fashion brands can appeal to a wider audience, including consumers who are not yet fully committed to sustainable choices. If a new style doesn't resonate with customers, brands risk having excess inventory that is difficult to sell. Before committing to physical clothing production, virtual prototypes might mitigate potential losses and minimize risks associated with introducing a new style that respects the diverse preferences and comfort levels of consumers while gradually introducing them to the zero-waste approach aesthetics.

To provide further insight into these assertions, this research paper considers two cases of virtual clothing production through distinct and eye-catching aesthetics of high-street fashion while using the

zero-waste approach in reducing fabric remnants. The first case involves a blouse with a fabric consumption of 99.82% and the second case involves a skirt with a fabric consumption of 97.63%. The results have been obtained using the software program.

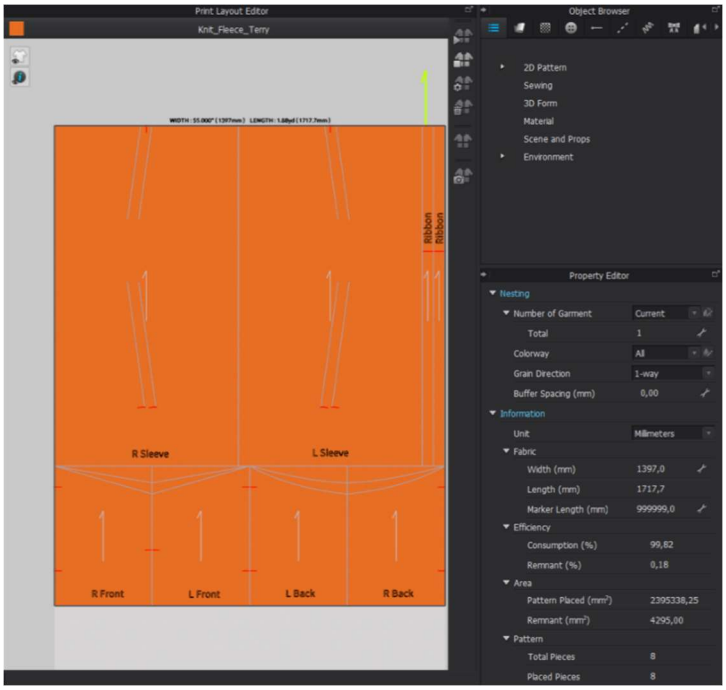

Figure 1. Marker with blouse pattern pieces.

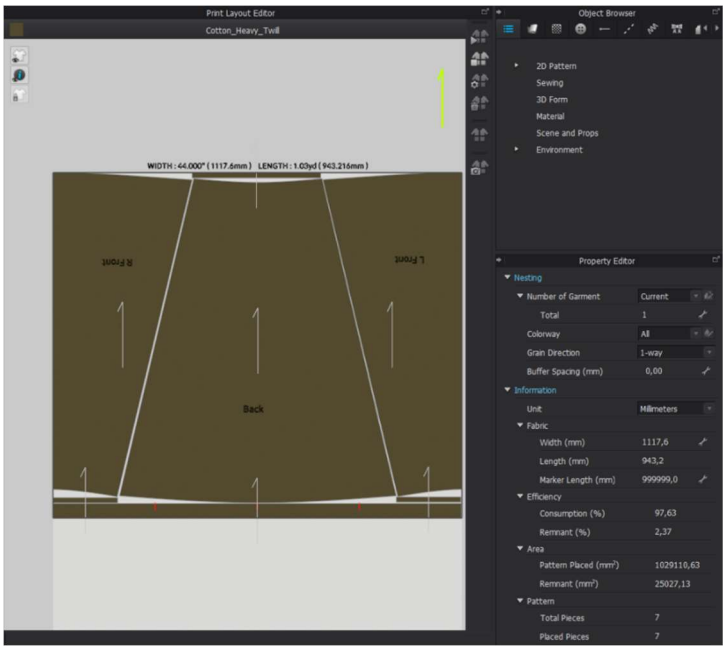

Figure 2. Marker with skirt pattern pieces.

Earlier professional training in software programs specialized for the fashion industry revealed that they can offer many benefits in reducing fabric remnants. Software programs are fast and cost-effective, currently used in the domain of clothing production processes, rarely crossing over into fashion design. However, the development of new software programs combines these areas with state-of-the-art

simulation technologies (e.g., CLO). The efficiencies software programs bring, whether in time or fabric consumption, are welcome, as the zero-waste approach needs to justify the time, labor, and costs required for manual design and production Nonetheless, this makes software programs extremely important for clothing production processes.

The CLO software program, that creates virtual, true-to-life clothing visualization, was used in this research paper for 2D pattern-making, marker/print layout, 3D simulation, and rendering. The observation made was that the CLO software program exhibited significant limitations when it came to pattern nesting. Software program's limitations, in adhering to a zero-waste approach pattern nesting, highlight the need for technological advancements in the fashion industry. These software program tools might not have the capabilities to easily accommodate complex zero-waste approach patterns. Even though, the software program offers a wide range of tools for adjusting patterns, altering designs, and experimenting with different colors and textures.

With CLO, designers can virtually create and simulate clothing in a 3D environment. This virtual prototyping allows them to visualize how the garments will appear and behave on virtual models before any physical prototypes are made. The software program CLO's clothing simulation of both cases provided a true-to-life representation of how fabrics drape, stretch, and interact with the body, aiding in design accuracy.

Figure 3. 3D simulation of blouse and skirt.

The 3D simulations provide a clearer visualization of the final product compared to traditional 2D drawings. This helps designers communicate their ideas effectively to team members, stakeholders, and consumers. By identifying potential fashion design flaws or fit issues in the virtual environment, designers can address these problems before moving to the physical production phase, reducing the risk of costly errors. The CLO reduces the cost and time eliminating the need to create physical prototypes for each design iteration.

In the 3D environment garments may appear flat or lack the depth and realism that real-life lighting and reflection provide. Lighting plays a critical role in how clothing is perceived visually. Shadows, highlights, and reflections from different light sources contribute to the overall appearance of the clothing. Rendering involves complex calculations to simulate the behavior of light in a virtual environment. It takes into account factors such as the fabric properties, texture, geometry, and the placement of light sources. The rendering process calculates how light rays interact with the surfaces of the 3D clothing model, determining how they are absorbed, scattered, or reflected. By incorporating realistic lighting effects, rendering enhances the visual quality of the 3D clothing, making it appear as if it is placed in a real-world setting under actual lighting conditions. Rendering transforms the 3D clothing model into a photo-realistic image or animation that closely resembles how the clothing would look in a physical environment. Photo-realistic renderings allow designers to showcase their creations

in a visually appealing and accurate manner. Fashion brands often use rendered images for marketing purposes, as they provide a preview of how the clothing would appear when worn by a real person.

Figure 4. Photo-realistic rendering.

This facilitates the identification of potential fitting issues early in the design process, preventing the need for multiple physical fittings and alterations, and reducing the likelihood of misinterpretations that could lead to wasted resources [15].

7. Conclusion

The general benefit of clothing production with high-street fashion aesthetics using a zero-waste approach can be summarized in several areas: extended lifecycle of clothing, increased versatility of clothing styles, promoted redesign/reuse solutions, reduced excessive fashion waste, and perhaps enhanced consumer satisfaction with alternative styles over time. In the two cases of virtual clothing production, the aim of this research paper was to consider how fashion brands can successfully balance the aesthetic preferences of high-street fashion consumers with sustainability imperatives. More precisely, these two cases demonstrate the feasibility of creating appealing fashion designs for high-street fashion consumers by integrating the zero-waste approach into clothing production processes.

Fashion designers should continue exploring various design methods to offer accessible clothing that meets global aspirations and urges for sustainability. Also, it's important to understand how consumers

react, engage, and interact with the specific design. Therefore, it's crucial for fashion designers to provide consumers with opportunities to participate in the creative process in the experimental phase of fashion design. Besides fashion design, integrating the zero-waste approach in the clothing production processes involves a collaborative effort of fashion designers, entrepreneurs, manufacturers, and consumers. While this research paper provides valuable insights into these intersections, it also represents a starting point for investigating and removing certain limitations. These limitations emphasize the need for continuous inquiry and collaboration of stakeholders to fully use the potential of sustainable clothing production. As the fashion industry navigates toward responsible practices, future research should explore the dynamics of these interactions, examining how various stakeholders can collectively drive change. As consumers have an influential role in shaping aesthetic preferences, their awareness and understanding of sustainable principles is essential for driving meaningful change.

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Wool as a sustainable medium for creative expression in art

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Abstract. In recent years, there has been an increasing fascination with wool as a medium for creative expression, diverging from its traditional role as fabric for functional items. This emergence of sustainable art merges time-honored wool techniques with modern innovation. Our study delves into the intersection of this unique art form and environmental responsibility, highlighting its potential to foster more conscientious practices. By promoting wool art, we can keep these traditional wool processing and weaving techniques alive, preserving them in the face of the environmental impact caused by the textile industry. Not only can wool art help raise awareness about this issue, but it also serves as a way to combat the demand for fast fashion and cheap textiles that has driven many traditional wool producers out of business in its entirety, the art of wool provides an unparalleled chance to contemplate our connection with the natural world, as well as the manners in which we engage with, utilize, and discard textile materials. For millennia, wool art has held a prominent place within human society, being widely recognized as one of the most environmentally-friendly forms of artistic expression. Utilizing wool as a medium allows artists to tap into the bountiful, renewable resources of nature without causing any harm to the environment or the animals involved. In the contemporary art world, wool art is gaining increasing significance due to multitudes of factors.

1. Introduction

Firstly, wool is an exceptionally sustainable material, often procured from local sources, thus allowing artists to make responsible choices that prioritize eco-friendliness and ethical sourcing. Additionally, wool art possesses a distinctive texture and warmth that engenders a profound sensory experience for viewers, introducing a tactile dimension to the artistic realm that is not always present in more conventional mediums. The realm of wool art encompasses a wide range of expressions, spanning from traditional tapestries to three-dimensional installations and even live performances. This versatility allows for the exploration and communication of a multitude of themes and concepts. Moreover, wool art serves as a means of challenging traditional gender roles, given its historical association with women artists, thereby challenging preconceived notions of what is considered "high art." This renders wool art a significant component of the contemporary art scene, fostering diversity and inclusivity in creative expression. The time-honored techniques employed in wool art have been passed down from one generation to the next, promoting sustainable practices in production. These techniques encompass hand spinning, weaving, felting, and dyeing. The utilization of natural dyes and fibers in wool art further advances sustainability, as they are biodegradable and devoid of harmful chemicals. Wool art also

contributes to sustainable consumption practices as it provides a unique and long-lasting form of decoration or clothing that can be passed down through families and communities. Wool art is an art form that uses wool as the main creative medium. These include techniques such as felting, knitting, weaving, and embroidery, which involve manipulating wool fibers to create different textures, shapes, and designs. Wool art can cover a variety of styles and themes, from traditional tapestries and rugs to modern sculptures and installations. It is a unique and versatile medium that can produce tactile, warm, and beautiful creations, making it an increasingly popular choice for contemporary artists and textile enthusiasts.

2. Importance of wool art in contemporary art scene

Wool art plays a vital role in the contemporary art scene and brings several important aspects. In a world dominated by digital media and mass-produced materials, Wool Art offers a refreshing point of departure. The artist uses wool as a medium to explore the potential of organic and sustainable materials. By incorporating wool into their artistic practice, contemporary artists challenge conventional notions of art materials and push the boundaries of artistic expression. Wool art often incorporates traditional techniques such as felting, spinning, and weaving, while honing the craft and skills required. These techniques have been practiced for centuries and have great cultural significance. Utilizing and reinventing them in contemporary art, Wool Art helps to preserve and revitalize these traditional practices, thereby bridging the gap between past and present. The tactile properties of wool create an immersive sensory experience in contemporary art. The texture and warmth of wool can evoke a range of emotions and inspire a deeper connection with a work of art. In a rapidly digitizing world, Wool Art offers viewers the opportunity to reconnect with their senses and experience tangible, tactile art. The contemporary art world is increasingly concerned with environmental issues, and Wool Art fits the growing focus on sustainability. Wool is a renewable, biodegradable and environmentally friendly material. Artists working with wool are committed to sustainable practices and a more conscious approach to art-making. By emphasizing wool as a medium, contemporary wool artists contribute to the conversation about environmental sustainability in art. The unique aesthetic of Wool Art offers unique aesthetic qualities that stand out in the contemporary art world. Wool's versatility allows artists to create visually appealing artwork that explores texture, shape and color. Whether in its minimalist aesthetic or intricate detailing, wool art has a unique and often unexpected visual impact, bringing diversity to the contemporary art landscape. Wool has deep cultural and historical significance in different parts of the world. Incorporating wool into their artwork, contemporary artists can tap into these rich cultural narratives and create connections with specific communities and traditions. This allows for the exploration of issues of identity, heritage and globalization, and encourages a wider and more diverse dialogue within the contemporary art world.

3. Significance of wool as a a medium for art

Due to its unique qualities and properties, wool has long been regarded as a versatile and important artistic medium. Wool fibers have a unique texture that adds depth and dimension to artistic creations. Whether felted, woven or embroidered, wool artwork often exhibits tactile qualities that appeal to the eyes and the senses. Additionally, the natural insulating properties of wool give the artwork a cozy and warm feel that is not only visually appealing but also physically comfortable. Wool can be used in a variety of artistic techniques, making it a versatile medium. From hand spinning and weaving to felting and dyeing, artists can explore the many possibilities of wool. Its adaptability allows for endless creative expression, whether it is sculpture, tapestry, wearable or mixed media artwork. As mentioned, wool is a sustainable material. It's renewable, biodegradable, and ethically sourced from sheep. The sustainability of wool as a medium fit with the growing demand for environmentally friendly art practices and caters to a conscious audience concerned with the environmental impact of art materials. Choosing wool as a medium allows artists to support sustainable practices and promote a greener art industry. Wool has a

rich history, deeply rooted in different cultures around the world. Wool has been used for functional and artistic purposes for centuries, and has cultural significance and storytelling power. From traditional tapestries and rugs to clothing worn at ceremonies and celebrations, wool art reflects cultural heritage, tradition and craftsmanship. By utilizing wool as a medium, artists can pay homage to these traditions and keep them alive in contemporary contexts.

Wool can hold symbolic meaning in art. Its associations with warmth, comfort, and protection can be used to convey emotions and messages in artistic creations. Its natural colors or dyed hues can represent different concepts, such as nature, earth, or spirituality. The symbolism of wool allows artists to add depth and narrative to their works, creating a deeper connection with viewers.

In summary, wool's texture, versatility, sustainability, cultural heritage, and symbolism make it a significant and valued medium for artistic expression. Its unique qualities add depth and dimension to artworks while also appealing to a conscious audience seeking sustainable and meaningful artistic experiences.

4. Historical background of wool art

Wool weaving dates back thousands of years and wool was one of the first fibers used by humans for clothing, housing and communal needs. Wool has been used to make fabrics since ancient times. Nomadic cultures such as the ancient Egyptians, Greeks and Persians mastered the production of wool and used it to make fabrics, tapestries and carpets. The techniques used in that period laid the foundation for the later artistic tradition of wool weaving. During the Middle Ages (5^{th}-15^{th} centuries), wool art became increasingly important, especially in the form of tapestries. These large textile artworks depict historical stories, religious scenes and intricate designs. Medieval tapestries, such as the famous Bayeux tapestry, highlight the skill of weavers who used wool as the main yarn. During the Renaissance and Baroque periods (14^{th} to 18^{th} centuries), wool remained the material of choice for tapestries, especially in Europe. Exquisite woolen tapestries adorned palaces and castles, reflecting the status and wealth of the aristocracy. These textiles often feature detailed storytelling, intricate patterns, and rich colors.

The advent of the Industrial Revolution in the 18^{th} century brought significant changes to the wool industry. Mass-produced textiles have replaced traditional manual techniques, leading to a decline in the art of knitting. However, the desire to preserve traditional techniques led to the establishment of workshops, such as William Morris's Arts and Crafts movement in the late 19^{th} century, which revived interest in the arts. wool. In the 20^{th} century, the art of wool weaving began to develop, moving away from traditional textiles and embracing more experimental forms.

5. Evolution of wool art over time

The development of yarn art over time has been marked by marked changes in technique, style, and purpose. Wool art was originally used mainly for functional and decorative purposes. Ancient civilizations used wool to make utilitarian clothing, blankets, tapestries, and rugs. Often involving simple patterns and basic techniques, these pieces emphasize utility and durability over artistic expression. During the Middle Ages, wool rugs became very important as an art form. Skilled weavers use techniques such as weaving, embroidery, and appliqué to depict intricate patterns, intricate stories, and detailed scenes. These tapestries adorned the walls of castles and palaces, reflecting the wealth and prestige of their owners. During the Renaissance and Baroque periods, the focus remained on luxurious wool rugs. These tapestries became coveted status symbols and were often commissioned by powerful patrons. With the advent of the Industrial Revolution, the art of wool underwent significant changes. Mass production techniques have replaced traditional labor-intensive methods and the emphasis has shifted from manual craftsmanship to cheap production. This transition led to a decline in traditional woolen art, but it also paved the way for innovation and accessibility. As industrialization progressed, the desire to preserve and revive traditional craft emerged. In the late 19^{th} and early 20^{th} centuries, movements such as the Arts

and Crafts movement, led by figures such as William Morris, sought to restore high-quality craftsmanship. This revival emphasized the value of craft skills and sparked a renewed interest in the art of wool. During the 20th century, woolen art underwent a significant expansion beyond traditional textiles. Artists began to explore the artistic potential of wool as a medium for sculptures, installations and mixed media. Pioneers like Sheila Hicks and Lenore Tawney experimented with techniques, materials and shapes, pushing the boundaries of wool art. In recent decades, woolen art has reflected broader changes in contemporary art practice. Artists use wool as a medium to explore conceptual ideas, address social and political issues, and challenge traditional artistic notions. In addition, the focus is again on sustainability and the natural properties of wool are increasingly taken into account in relation to environmental aspects. Overall, the development of the art of wool reveals a rich and varied history, from functional craftsmanship to decorative splendor to innovative contemporary expressions. Its transformation reflects the evolution of social contexts, artistic movements and constant exploration of the potential of this medium.

6. Pioneering artists in wool art

Several avant-garde artists have made significant contributions to the field of woolen art. This media's innovative techniques, innovative approach, and willingness to push boundaries have shaped its development and inspired generations to come. Sheila Hicks played an important role in expanding the possibilities of wool as an artistic medium. She experimented with color, texture, and form, creating large-scale installations, sculptures, and textiles. Hicks explores the tactile quality of wool and integrates it with other materials, blurring the line between craft and fine art [1]. Above all else, Hicks' work is unashamedly ebullient. Whether it takes the humble form of an intimate weaving or a series of giant puff balls in exuberant colors, such as her colossal installation Escalade Beyond Chromatic Lands Figure 1. for the current Venice Biennale, it begs to be touched, and audiences are welcomed to engage with it in a thwarting of the traditional white-box approach to exhibition [2]. Often referred to as the "mother of textile art"; Lenore Tawney was a key figure in the development of the art of wool. Her delicate yet sturdy weaves included wool, silk, and linen, pushing the boundaries of traditional tapestry techniques.

Figure 1. Sheila Hicks, Escalade Beyond Chromatic Lands, 2016-17, mixed media, natural and synthetic fibres, cloth, slate and bamboo, on display at the Venice Biennale, Italy.

Tawney's multifaceted work explored spirituality and emotional expression, influencing future generations of fiber artists. The 1960s and ’70s when much of this groundbreaking work gained notice saw the divisions between art and craft eroded by experimentation with nontraditional sculptural materials. Parallel developments occurred in the contemporary art world as artists such as Eva Hesse and Robert Morris began to use fiber in their process-based work. Hicks, now in her eighties, continues to be a renegade sculptor devoted to fiber, or as she often calls her medium, “the linear pliable element.” Magdalena Abakanowicz was a Polish sculptor and installation artist known for her impressive monumental sculptures made from wool fibers and other natural materials Figure 2. Figure 3. Her woven structures often dealt with themes of identity, vulnerability, and human experience. Abakanowicz's large-scale wool works are attracting attention and redefining the possibilities of using wool in sculpture. They were soft not hard; ambiguous and organic; towering works that hung from the ceiling and pioneered a new form of installation [3]. They became known as the Abakans.

Figure 2. Magdalena Abakanowicz, Abakan Red, 1969, sisal weaving on metal support.

Figure 3. Magdalena Abakanowicz, Abakan étroit, 1967/68, sisal and wool.

While Kiki Smith is best known for her diverse artistic practice, she has also made significant contributions to wool art. In her work, she often uses wool as a material and deals with themes such as the body, gender, and identity. Smith's fiber sculptures and installations combine the organic properties of wool with an introspective and poetic narrative. Anne Wilson is a contemporary artist who has explored the complexities of wool in her meticulous and conceptually rich works. She combines weaving, sewing, and drawing techniques, transforming wool into delicate and intricate shapes. Wilson's wool art examines cultural history, labor, and the interaction between the individual and the collective. These are just a few examples of avant-garde artists who have made significant contributions to the field of woolen art. Their innovative approach and experimentation have fueled the medium's development, inspiring the next generations of artists to explore the wool's expressive potential in their own unique way.

7. An Overview of the Current Wool Arts movement

The current wool art movement is dynamic and diverse, encompassing many different artistic approaches, styles, and themes. Today, artists are pushing the boundaries of wool, experimenting with new techniques, materials, and concepts. Contemporary wool artists continue to find creative ways to use wool as a material. They experiment with different types of wool, such as merino, alpaca, or mohair, and

combine them with other materials such as silk, linen, or metal. The artists also incorporate unique objects and found materials into their wool artwork, blurring the traditional boundaries of yarn art. Many contemporary wool artists are committed to sustainable and environmentally friendly practices. They typically source their wool from local ethical producers, ensuring sustainable farming practices and animal welfare. Some artists even use processes like natural dyeing or zero-waste techniques in their work. Today's wool art is not limited to traditional handicraft techniques but also includes contemporary, conceptual art techniques. Artists use wool to explore a variety of themes, including memory, identity, ecology, social justice, and cultural narrative. Concepts of fragility, tameness, and the body are recurring themes in wool art practice. Many contemporary wool artists create large-scale installations and living environments. These pieces often transform familiar spaces such as galleries or public spaces, using wool as a medium to create sensory experiences. Installations can include hanging wool sculptures, tactile wall hangings, or interactive installations that invite audience participation. Collaborations became increasingly popular in the wool art movement. Artists collaborate with weavers, textile designers, fashion designers, and other creative professionals to explore new possibilities and expand the artistic language of wool. Through collaboration, artists share techniques, expertise, and diverse perspectives to create innovative artwork and push boundaries. Wool art has also been used as a tool for social and cultural commentary. Artists use wool to address pressing issues of gender equality, labor rights, cultural heritage, and environmental degradation. These artists use wool as metaphorical material, engaging in important conversations and raising awareness of important global issues.

8. Examples of innovative applications of wool in art

British textile artist Richard McVetis' work has long explored the nuances inherent in habitual, labor-intensive manufacturing through repetition, ritual, rhythm and obsession. His Stitched Cube Variations, shortlisted for the 2018. Loewe Craft Prize, explore our system for measuring time Figure 4. Figure 5. Often three-dimensional and cubic, these unique textile pieces attempt to capture human presence, time and decay through careful stitching [4]. This is a portrait of the artist and of the human condition in general.

Figure 4. Richard McVetis, Units of Time, 2015, hand embroidery, cotton on wool.

Figure 5. Richard McVetis, Variations of a Stitched Cube, 2017.

Chiharu Shiota's intricate weaves are unforgettable and easy to get lost in. Her maze-like installations are giant, surreal waves of blood-red, black, or white threads, almost as if humans could weave webs. In these settings, the Berlin-based Japanese artist often captures objects of personal significance, such as clothes, keys, boats, suitcases, and even herself. Shiota's work is deeply rooted in performance art. The artist studied under Marina Abramović, and maintains a strong relationship with the late Cuban-American artist Ana Mendieta. Her textile installations are both performative and painterly. Shiota's beautiful and disturbing works express the intangible: memories, dreams, anxiety, and silence [5]. The work known as

In Silence is inspired by Shiota's own traumatic memories as a child, having witnessed her neighbor's house burn down. The charred piano is a direct memory of her neighbor's grand piano blazed up in smoke Figure 5 Figure 6. There is a melancholic aura that hovers throughout the incinerated room filled with singed furniture [5].

Figure 6. Chiharu Shiota, In silence. Bienne, 2008.

Figure 7. Chiharu Shiota, In silence. Bienne, 2008.

Flokati rugs became a style icon in the 1960s and 70s after Haute hippies began to adopt them for their interiors. Today, a particularly rare breed of these fluffy woolen floor coverings finds its way into the residences of the international beau monde thanks to the artist Anna Betbeze, who adopted flokatis as her canvas. In her work, which erases the boundaries between sculpture and painting, she uses flokatis as the medium of his creativity. She bleaches the hand-woven carpets she buys from private homes in Macedonia, buries them in the ground, and then coats them with colorful pigments. Ayse Birsel, a Turkish-born designer, has incorporated wool into her tapestry artwork in a fresh and contemporary way.

Her "Wool Tapestry" series combines traditional weaving techniques with modern design sensibilities. Birsel experiments with different weights and textures of wool to create intricate patterns and bold color combinations, resulting in vibrant tapestries that showcase the versatility and visual impact of wool as a fiber for woven art.

9.Conclusion

Wool art is an important and beautiful medium that has significant environmental and ethical considerations. As the demand for sustainable and ethical practices grows, wool artists must consider their role in promoting these practices [6]. By exploring strategies for sustainable and ethical wool production, consumption, and disposal, wool artists can contribute to a more sustainable and equitable future. Each artist brings their distinctive approach to wool, resulting in captivating and thought-provoking artworks. From Shiota's beautiful and disturbing works express the intangible: memories, dreams, anxiety, and silence to Betbeze's textured and emotive wool paintings, the artists explore different dimensions of the material. These artists not only contribute to the field of contemporary art but also shed light on the sustainability and versatility of wool as a material [7]. Through their innovative use of wool, they remind us of its significance and potential within the artistic realm and encourage further exploration and experimentation in this medium. Overall, the theme of using wool in art celebrates the boundless creativity of artists and the transformative power of materials, inspiring us to appreciate the beauty and potential within the ordinary [8].

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Art, clothes and Yugoslavia: design of a working man in SFRJ

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Abstract: Visual imagery and production, as well as design itself within the framework of the Socialist Federal Republic of Yugoslavia, was basing itself on the state ideology, the myth of Josip Broz Tito and the idea of "brotherhood and unity". The Socialist Republic of Yugoslavia has characterized as a power in the Balkans that was rapidly expanding, forged on socialist ideas; a republic that burned bright and burned down, all in a matter of decades. The aesthetic of the working class and the worker-individual was meticulously designed and executed to follow the set mantra of the period. In addition to artistic and visual presentation of general design, an important role was also played by clothing as a means of affirming political, social and cultural ideas - the costume one wears conveying a clear message. In addition to everything, visual culture, design and clothing were exposed to influences set by the consumerist trends of the capitalist West. In that context, workers' clothing, as well as pioneer clothing, and that of youth work actions volunteers, were based on socialist colors and ideals of Yugoslavia, entirely divorced from trends set by its western contemporaries. Sewn to accommodate state organized working actions, as well as organizations made for social inaugurations of young people, brigade flags, clothes and shoes were made to equip entire towns and regions. The main goal of this work is to look back on this historical phenomenon, the meticulous design that followed it all in the sake of promoting state ideals, as well as to research about who exactly were the main heroes without names and faces - the workers of Yugoslavia.

1. Introduction

The Socialist Federal Republic of Yugoslavia has left a historical mark on the Balkans as a powerful force that quickly built itself up, but crumbled down even faster. It was unique in every sense, and was one of the founding nations of the Non-Aligned Bloc. Through Tito's rule, it was founded on a combination of liberal ideas with a government that had a one party system. [1] Yugoslavia also had its own symbols, and the nation was indoctrinated with ideological ideals, all of which were undeniably reflected in the designs of that era. Designers worked both to strengthen the industry as well as fuel the government's propaganda, whose work mirrored the socialist regime that ruled at the time. Fashion, art, political endeavors and work actions of young people all carriedwith them symbols and colors that designers integrated into their work. From the mass reconstruction projects of the country after the end of the Second World War, Youth Work Actions (ORAs) eventually became one of the standard rituals of indoctrination of young people into this socialist society, such as

handing over the baton to Josip Broz Tito or gaining a membership in the Yugoslav Union of Pioneers. [1] Whole settlements were built and equipped for actions and social inaugurations of young people that for lasted several years. Brigade flags were sewn, clothes and shoes were produced, textile labels on sleeves were made for such events. The aim of this work is to look back on this historical phenomenon, as well as to see who the main heroes without names and faces were - the workers.

2. Yugoslavia and it's garment aesthetics

Yugoslavia was, above all, a socialist power in Europe, situated on the thin middle line between the total collectivization and individualization of its people. More of a collective spirit than the capitalist West, and a system that at the same time turns more to individualistic philosophies than the communist East. Founded in 1946 after Josip Broz Tito and his communist-led partisans helped liberate the country from German rule in 1944–45. year, this second Yugoslavia covered almost the same territory as its predecessor, with the addition of land acquired from Italy in Istria and Dalmatia. The kingdom was replaced by a federation of six nominally equal republics: Croatia, Montenegro, Serbia, Slovenia, Bosnia and Herzegovina and Macedonia. In Serbia, the two provinces of Kosovo and Vojvodina were granted autonomous status in order to respect the specific interests of the Albanians and the Hungarians. Despite this federal form, the new state was initially highly centralized both politically and economically, with power firmly held by Tito's Communist Party of Yugoslavia and a constitution modeled after that of the Soviet Union. [1]

In the first years after the Second World War, a complete reorganization of the state began in all fields (cultural, economic and political) according to the communist revolutionary principles. In order to ensure prosperity and the fastest possible exit from the post-war crisis in which the country found itself, special attention was paid to young people and "ordinary people", i.e. their ideological-political renovation. It was first of all important to ensure the existence of a well-educated people, and it focused even more on additional education, opening schools and providing equal opportunities to all citizens. This socialist ideology found its way deep into all cultural and educational spheres of Yugoslavia, which was made up of nations whose inhabitants were neither literate nor equipped for the 20th century and its industrialization.

Economically speaking, Tito envisioned a "third party nation", to ensure Yugoslavia could cooperate with both the East and the West, without either of them dominating its market. Small businesses existed in such a regime even though most of the large industries were nationalized, although those business owners could not become rich in a way westerners could, but they still could accumulate their small wealth, enough to live a financially stable life, while also owning a fancy car, vacation home, imports from the west and other small luxuries. By some GDP and other economic measures, Yugoslavia was sometimes more prosperous than poorer capitalist European countries like Italy or Greece. This experience with a market economy benefited the Yugoslavs when the Eastern European communist regimes finally fell. [2] Coined during the National Liberation Struggle of Yugoslavia (1941-45), the slogan "Brotherhood and Unity" was an ideal celebrated in Yugoslavia by both the League of Communists of Yugoslavia as well as the people of this nation. As one of the three main dogmas of the ideologues of "Titoism", brotherhood and unity represented resolved inter-ethnic relations in Yugoslavia. [3] To extinguish any possible or existing hatred between Yugoslavian numerous national, ethnic and religious groups, The Communist Party of Yugoslavia successfully promoted this ideology against their enemies after the Nazi invasion in April 1941, as a means of fighting against fascist forces and their local collaborators. Under such an ideal, every individual no matter the nationality had the right to express their own culture and religion, while pledging to maintain peaceful relations, with everyone getting encouraged to call themselves Yugoslavs. It was integrated into the nation's everyday life through many factories, schools, public places, heritage (folklore) ensembles and sports teams bearing the name "Brotherhood and Unity". [4]

2.1. Union of Pioneers of Yugoslavia

The Union of Pioneers of Yugoslavia represented a massive children's organization that emerged from 1950 throughout the changes associated with the much wider de-Soviet social reform. Organization for meant for school children of ages from seven to fourteen was connected to the National Youth of Yugoslavia, but with the systemic changes that occurred, it turned to a more educational and entertainment approach, whilst contributing to the development of patriotism and building faith in socialism among the young members.

The Union of Pioneers of Yugoslavia was founded in Bihać, in Bosnia and Herzegovina, on December 27, 1942, during the First Congress of the United Union of Anti-Fascist Youth of Yugoslavia. Two mass social organizations - pioneer and youth - remained closely connected in their work with pioneers and youth for the next eight years, and the cooperation continued in a different way later on. Gathering children between the ages of seven and fourteen, until their transition to youth, the Union of Pioneers cooperated with other socialist organizations and greatly contributed to the development of a sense of patriotism and faith in socialism among the youngest, who were the easiest to absorb new ideas. In the post-war period, the association gathered children in reconstruction (reconstructive projects) actions, and then more and more in various extracurricular activities, ceremonies on national holidays and protocol occasions. The direct model for the founding of the Union of Pioneers was a similar organization in the Soviet Union, and similar forms of association and activity were carried out in other countries of state socialism. As the Soviet socialist model ceased to be an unquestionable role model in Yugoslavia in 1948, as a result of the de-Sovietization, the Union of Pioneers also had to undergo reform. Ideas emphasizing the need for stronger party involvement in the mobilization of organizations in providing assistance to schools, but also confirming that "molded thinking" is unacceptable for a socialist man. The following year the Croatian Agitprop pointed out that it was necessary to "form the image of a new man" and expressed its views on the tasks of educators "with regard to the education of the new citizen of our country" and that in schools one should be "irreconcilable towards the enemy, build fighters for the implementation of the Five-Year Plan and socialism". During the fifties, ideas about building children as "positive personalities" were repeated, but also about the socialist man as a "free creative personality". It was indeed a utopian belief that through education and upbringing at the earliest age "it is possible to change the world through the truly different persons that socialism intended to 'produce'". [5]

It is necessary to take a closer look at several of the points from the initiation ceremony: the scarf and cap as part of the uniform, the vow and the role of a military officer. At the very beginning of the fifties, the issue of the pioneer uniform and symbols was still not clearly resolved. The pioneer flag, trumpet and drum and the salute "For the homeland with Tito - forward!" were also in use. Soon a simple uniform for pioneers was introduced: blue pants or skirts (depending on the sex of the kid), white shirt or blouse and a red scarf around the neck topped with a blue pioneer cap. The main symbol at that time were the triangular-shaped pioneer scarves which could be "multi-colored, according to the color and sign of the group". It was not until the Regulations of the Association of Pioneers of Croatia from 1952 that it was determined that scarves must be red. The red color of the scarf came from the red flag of the pioneers, and it was found that as such "part of the flag of the Communist Party, and that is why the pioneers keep it as the brightest symbol of their organization". However, the headscarf, although a very simple pioneer symbol, caused a number of worries on the ground because the organizers of the initiation ceremonies had to get them as well as pay for them on time. It was best to do this through the Union of Our Children Society (Savez Društvo Naša Djeca - SDND), which sold pioneer equipment and would send a price list upon request, but due to poor preparations in some detachments, pioneers were without a headscarf, which was at that point in time the one and only symbol which was supposed to remind them oftheir vow. In 1954, only half of the Croatian pioneers had scarves and hats. The issue of the pioneer cap was even more complex.

Figure 1. Set of images showing a pioneer child with a text written on each picture: Honest, Sincere, Loyal, Steadfast, Truthful, Radiant ("Pošten, Iskren, Odan, Nepokolebljiv, Istinoljubiv, Radišan").

Namely, although at that time it was not mentioned in the regulations as part of the equipment, it can be found as early as 1951 in the advertisement of the magazine "Naša djeca" (Our Children) as an item that can be ordered. Photographs from the 1950s show pioneers without caps, with a white three-cornered cap, a plain white cap, and only in the second half of the decade can a blue cap be seen, which, like its predecessors, has a red five-pointed star on the front, and increasingly often a pioneer badge on the side are the left-facing faces of a pioneer and a pioneer woman, a pioneer salute, a branch and a star. Judging from the photographs alone, it can be tentatively concluded that the duality of white and blue caps existed between 1955 and 1959, but those caps that the pioneers received before 1955 still retained their white color, provided they received them at all. Only with the introduction of the red headscarf and the blue cap of the uniform of the pioneers of Yugoslavia was created a completed image of socialist symbols: Yugoslavian blue-white-red using the cap, face and headscarf. [5]

3. Early Yugoslav fashion and design breakthrough

With the end of WWII, Yugoslavia's clothing industry was far from modern ad fashionable due to the poor financial and material state the country found itself in. Such was the clothing and textile well until the late 50s, with many citizens deeming the garments unsatisfactory, as these pieces were mere copies of uniforms with simple constructions in mind. Central Yugoslavian textile and clothing industries were not established, as opposed to soviet (as well as other communist Eastern European) systems, in which Yugoslavia wanted to make itself presentable and interesting to Western markets. [6] With the rapid industrialization of the country, the textile industry was notable for their employment rates during the cultural and economic renovation, with many women who had basic education finding their place in the workforce, which also marked the start of Yugoslavian fashion industry. While still struggling with the "socialist good taste", the fashion industry slowly started to make a name for itself and has gotten more people interested in its wares, being a changing point for improvement of the modern urban lifestyle in the socialist regime. The influences of western fashion were noticeable, even though designers toned anything they considered "too much" down. The socialist ideal of good taste did not manage to last long, as people got bored of a sterile look

pushed by the industry and have started demanding for more, which prompted change in both production and design philosophies of the 50s, to a more extravagant and modern fashion style, featuring exotic motifs and designs emerged [7]

During the late 50s, to still uphold the "socialist good taste" while also referencing and imitating Western fashion, it was of utmost essence to socialist designers to not go over the top with color usage, silhouettes and patterns. That restrictive color palette left a lot to be desired, especially for women consumers, but that norm was upheld by political figures who were mostly seen wearing pastel, beige, green and black colors, to not draw too much attention and to reinforce the "people's person" image. The neutral colors very well aligned with that socialist ideology, as well as it was a look many workers dressed in during the first stages of Yugoslavia's urbanization. Thus, extremes were also warned against in beauty magazines, in fashion advice related rubrics. Even though fashion wasn't state-controlled, disappointment and rebellion towards it rose, which didn't go unnoticed. In the year of 1956, the state massively increased the amount of fashionable garments imported from different, mostly Western countries, spending roughly 10 billion dinars on imported textiles and clothes. [7] Since the early sixties and onwards, Yugoslavian fashion became similar, if not identical, to the fashion of Western Europe, following trends set by Hollywood, rock'n'roll stars and other pop cultural shifts.

4. Yugoslav workers and pop-culture influence during the second half of the 20th century

The development of popular culture in socialist Yugoslavia was possible with the liberalization and modernization of the country, whereby the 1950s and 1960s were crucial for the establishment ofideological and cultural paradigms according to which Yugoslav popular culture developed. Its role was tooffer quality entertainment and meet the social needs of socialist people in accordance with the propagatedideology. In doing so, self-management and openness to the West played a key role. Although a return to the primary Marxist principles of culture creation from below, by the people, was an ideological imperative,the field of popular culture was never completely left to direct democratic or commercial regulation. In thecreation of a specific Yugoslav popular culture, several processes were of formative importance: modernization and urbanization, acceptance of entertainment as an indispensable part of everyday life, andmoderation as a key component of good taste. Therefore, on the examples of popular music, television andfashion, it is possible to recognize the relationship of Yugoslav socialism to the meaning and potential of popular cultural practices. In that space between ideology and entertainment as a part of everyday life, thesocialist man with his desires and needs acts as a decisive element in the final definition of Yugoslav popularculture. [8]

The concept of popular culture originated in the United States of America in the 1950s. The reason for this was the end of the Second World War and the sudden increase of purchasing power after that. The population increased rapidly and young people became more socially active, they were eager for change and thus were characterized as rebels. In that period, a number of trends emerged, some of which were the worship of Elvis, jeans, the fight for gay rights, hippies, punk and a number of others. Precisely because of the fact that popular culture is considered a culture that is "carried on the backs of younger generations". However, although young people were at the center of these events, there are a number of examples that prove that popular culture is enjoyed by people of all ages. The fact that popular culture is "consumed" and "enjoyed" by a mass of people makes it the most difficult part of the cultural industry to define, but also to control." It is almost impossible to give a single definition of popular culture that would encompass all its features and essential elements that it characterizes. In addition to the fact that "popular" is a concept that is abstract to its core, the concept of culture does not have a single definition either, but has over a dozen of them. While on the one hand culture is described as a system of beliefs, rituals, symbols, language and the like, on the other hand it is defined as the relationship of all the previously mentioned elements. Therefore, culture can be perceived as a pattern according to which each individual shapes his own view of the world. The word popular comes from the Greek word populus which means the people. Although popular culture is defined as the culture of the people or individuals, it is still not possible to accurately determine whether it really comes from the people or is promoted by certain power structures in order to achieve their stated goals. Although it cannot be precisely defined, it is clear that a person in such a situation

is not just a passive consumer, but quite the opposite. The consumer himself decides what to consume and whether he will consume anything at all, they create their own meanings and produce new forms of popular culture themselves. They observes, analyze and critically evaluate new forms in order to come to the conclusion whether the new form is valid or not. [8]

Figure 2. The rise of pop culture, fashion and technology in the 70s and 80s (magazine "Računari", from September 1986)

Of course, this is an ideal that should be acted upon, which is not always the case. These rules apply to consumers, but not to all people. Some people live their lives "strictly looking forward" without any other aspirations and interests, while other people, supporters of popular culture, strive to consume it alone. This is where the division into active and passive consumers occurs. In popular culture, the audienceis not considered a passive recipient. From the beginning of the existence of Yugoslavia until the end of the seventies of the twentieth century, one can notice the alternation of two periods - crisis and prosperity. The 1970s were known as a period of great political turmoil, but it is an interesting fact that in the same period the economy was in an extremely favorable position. Yugoslavia was always identified with only one man who was considered the father of said republic, so many wondered what would happen to it when Josip Broz Tito died. This very event, which took place in 1980, is considered a turning point in the development of the country, that is, it divides the history of Yugoslavia into two parts. From the very beginning, the 1980s, if one takes into account such a big change to the head of state, showed that a series of radical changes would take place. The first and biggest change was the awakening of the citizens' consciousness, who were suddenly faced with an economic crisis and a large external debt and were forced to wake up from the "pink dream" in which they had been living until then.

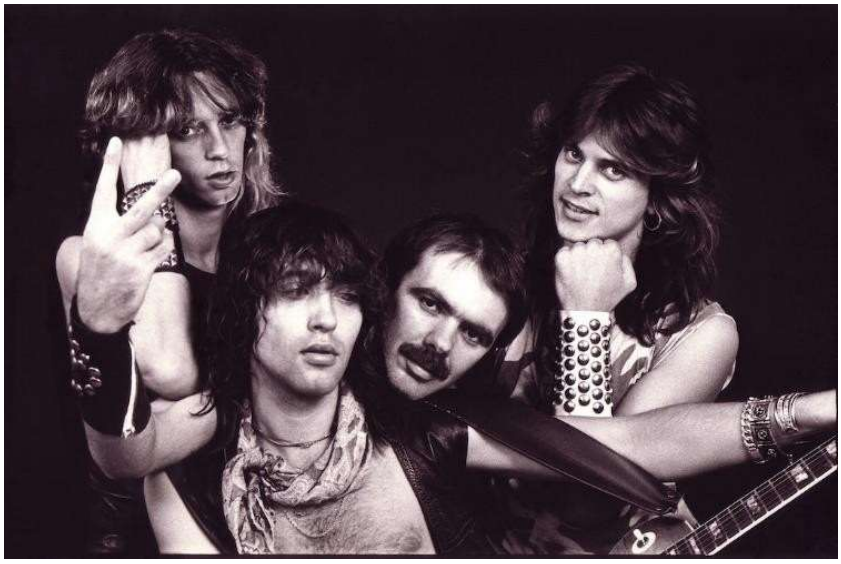

Figure 3. Bosnian band Divlje Jagode, inspiration to many “metal-head” Yugoslavs that were joining the alternative subcultures of the 80s (promotional picture of Divlje Jagode from the 80s)

The influence of the West and America on Yugoslav pop culture is undeniable, leading to the term "Coca-Cola socialism". This term is closely related to Yugoslavia and is seen as a historian's comment on the close connection that was created between Western ideals and Yugoslavia at the end of the 60s of the last century. After the conflict with the Eastern Bloc, Tito turned to the United States of America for support and inspiration. In the political sphere, the distance between the two countries was carefully maintained, but in the area of culture and consumption, the Yugoslav regime was definitely much more receptive to the American model. For Tito’s Yugoslavia, this tactic proved useful, stabilizing the regime internally and creating an image of openness in foreign policy. Coca-Cola socialism represents a link between cultural diplomacy, culture, consumers and politics. [9]

By the 1980s, the Americanization of culture was completely sealed, which was first of all noticeable in the fashion and music that young people subscribed to. The workers as heroes were placed less and less in the foreground. Nevertheless, workers and socialist attitudes were still found in the media and art, although now in a less idealized light. The bands, directors and artists of the time used the former symbols of national heroes as inspiration, portraying them in a more realistic image than ever before. In contrast to the illustrations of clean and strong workers shown in propaganda illustrations a few decades ago, workers were now given human roles, much messier descriptions, but without disrespect to them. One example of such workers can be found in the song of the Bihać band Divlje Jagode - Metalni Radnici (Metal Workers).A play on words on the increasingly popular genre of that era, metal, the song describes the arduous day ofphysical workers, unsung heroes, who with their work sustain the lives of others who do not think about them. A song about the ideal socialist man, whose purpose is not to seek glory for his efforts, but selflesslysurrenders to his goal of working for his country and people. In the hyper-masculine descriptions, one can notice the influence of the American culture of action heroes, which the musicians present through the textwith the closing words and convincing the listeners that "they can do it". At the same time, the poem can be felt as a subtle criticism of the unrealistic expectations of complete dedication to hard work in order to achieve the "heroic" status of a worker.

5. Conclusion

Although marked by crisis and tragedy, Yugoslavia saw changes and icons that sealed their place in history. In the twentieth century, which was marked by numerous and radical changes, different artistic trends experienced significant changes under the influence of not only social, economic, political, worldview and

numerous other changes, but also scientific and technological achievements. Design particularly stood out as a branch that matured in Yugoslavia, among people who were not familiar with this artistic technique until then. Thanks to the rapid industrialization and the movement for mass education, the inhabitants of Yugoslavia finally got out of the poor and archaic way of life that marked those areas in the centuries before. These positive aspects helped in propagating the wishes of the Communist Party, which managed to win over their people, at least for a short time, and managed to make the people feel like heroes and parts of a bigger picture, as well as a united nation.

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Strategic management and how to reduce the Bosnian and Herzegovinian "brain drain" of human resources as a critical development factor

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Abstract. Bosnian-Herzegovinian society does not keep up with the times. Lagging behind the developed world which, in the face of a permanent economic crisis, is re-examining the functioning of the established (capitalist) system and especially new management techniques, looking for solutions suitable for today's moment. Our country faces numerous economic and political crises and obstacles on its transition and development path. We have significant natural and human resources that we do not use sufficiently and in the right way. In addition to all the weaknesses in certain areas of social life and activity, major role has the economic diaspora, which is mostly made of young and educated personnel who, in a significant level prove to be, with their knowledge, abilities and skills, very capable and competitive in labor markets abroad. Unfortunately, their departure from the country, in addition to the worsening demographic picture, also impoverishes the human side of the base required for necessary strategic changes. There is a strong connection between the development of the country and the development of human resources. From this, comes the functional interdependence of the strategic mitigation of the "brain drain", where a stronger and wider strategic base of human resources leads to the sustainable development of our country. It is necessary to approach the creation and actual implementation of a socioeconomic development strategy, in which one of the key roles must be the strategy against excessive migrations of the most productive part of our population. This is actually the central topic of this article.

1. Introduction

We are witnessing that the world is rapidly and constantly changing and that there are various serious and deep crises around us that require an adequate response. The gap between the rich and the poor is widening as a result of income inequality among people. This affects migration flows, which are accelerating, and one of the trends that is present is the departure of an increasing number of high-quality and highly educated human resources. Bosnia and Herzegovina is not exempt from these trends, and although there are no precise statistics, it is clear that it is losing its population through the process of emigration, and among them is a significant proportion of young and educated people. A critical factor in socio-economic development is high-quality human resources, and Bosnia and Herzegovina has an imperative to mitigate these processes and reduce the brain drain.

2. A theoretical view of the world that is changing

The global processes taking place warn that a self-regulating competitive market driven economy does not offer ready-made solutions for all problems - a new society is emerging. In some past times, you could believe in the market and its mechanisms and that it would effectively manage global economic movements, enable constant growth, be a significant factor in resolving contentious political issues. Today, hardly anyone would dare to claim the same? New technologies, inflation, frequent changes in reference interest rates, green economy and climate change, digitalization, security, disruptions in

supply chains and increased migration, strengthening of authoritarian regimes, the rise of nationalist and religious supremacy movements, the rise of populism and the gradual abandonment of multilateralism indicate the end of the omnipotence of the market - new solutions are being sought for the new capitalism. In general, a redefinition of the current way of life is required.

Founder and Executive Chairman of World Economic Forum Klaus Schwab and his associate Thierry Malleret write about the need for a big reset [1] and a big narrative [2] for a better future with a focus on stakeholder capitalism. There are several reasons why it is not easy to diagnose the current state of affairs. The world has never before been so complex, interdependent, with exponential economic, scientific and technical growth, but also faced with many crises. Extraordinarily complex, challenging, and fast-moving industries demand from managers to make on-the-spot decisions and adapt to rapidly changing circumstances, while keeping the big picture in mind. The existing economic conceptual apparatus is inappropriate for contemporary events. Paradigm change - the end of the "orthodox economy" and the beginning of the "green transition" with a general conclusion: another way of doing business is required, but also strategic management on new bases as a common denominator.

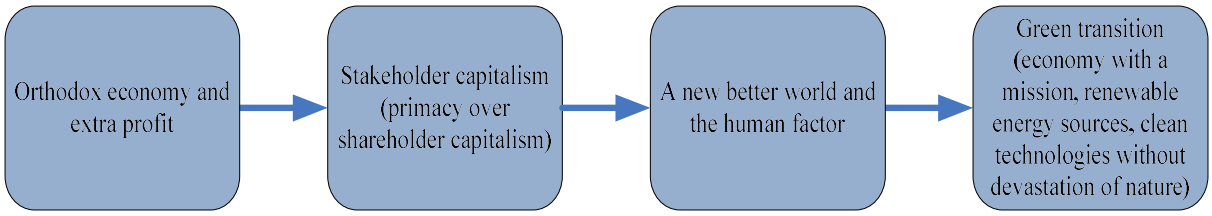

Figure 1. Changing the paradigm of the global economy.

Thomas Homer Dixon and Johan Rockstrom [3], on the other hand, in the context of the emergence of a large number of different crises, write that it only seems that the world is facing a "perfect storm" of simultaneous crises and that this simultaneity is an unfortunate and temporary coincidence. They believe that it is a global polycrisis. We are facing seemingly different, but deeply connected crises, which makes them much more dangerous than if they were individual cases:

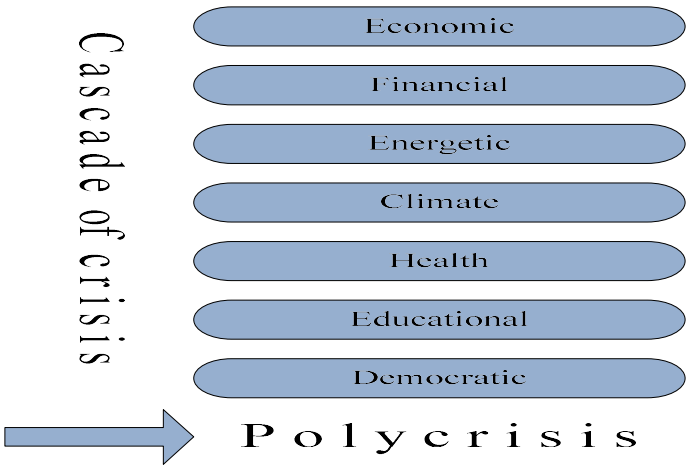

Figure 2. The appearance of a global polycrisis.

The polycrisis affected the existence of a large number of people, disrupted the business activities of companies and exposed many shortcomings in the health, education and socio-economic systems. Back in 2007, Naomi Klein [4] claimed that the world economy is dominated by the process of transforming society through the "shock doctrine", as radical neoliberal policies that were used after certain shocks (natural disasters, wars, etc.) to implement privatization processes, deregulation of the market, reduction of public spending.

As it turned out later, this resulted in an increase in the gap between the rich and the poor and the transfer of power to corporate elites. Growing inequality has fueled the perception that 52% of respondents believe that today's capitalism does more bad than good. [5] It is evident that something must change, and more and more theoreticians such as Thomas Piketty [6] write about the necessity introduction of a universal basic income, especially for young people and students, or Daniel Chandler [7], who calls for equality and justice to become a reality by applying the ideas of the liberal philosopher John Rawls.

What does that have to do with us - the Bosnian-Herzegovinian society? How to survive in such a global environment and strategically create and implement sustainable development? These are key questions.

3. The current situation and the necessity of changes

Bosnia and Herzegovina is a small country with weak economic power, which due to its political structure does not have a single economic space. The initiated transition processes have slowed down, which leads to insufficient economic growth and lagging behind the neighboring countries. It is a process that lasts a long time and therefore becomes a constant. Let us list some of the indicators of today's situation:

• Permanently high unemployment – in March 2023, the number of registered unemployed in Bosnia and Herzegovina was 352,890 as a result of low economic activity [8]
• Permanently high youth unemployment - 36.6% in 2020 compared to 17.5% in the EU, among other things, as a result of insufficient adaptation to the demands of the labor market [9]
• Unfavorable demographic trends – the current trend of worsening natural growth (in 2021 was -23,190) and a continuous decline in the number of graduate students in Bosnia and Herzegovina (12,324 in 2021), which increases the gap compared to EU countries (around 12% fewer people with completed tertiary education) [10]
• Imbalance of export and import: Export-Import Coverage Ratio is only 66% [11]
• Insufficient investment, especially direct investment
• Insufficient number of business entities with a low level of organization and efficiency
• Weak competitiveness of companies based only on low labor costs
• Technical and technological lagging behind contemporary trends
• Insufficiently implemented digital transformation process

To this should be added high public spending as the basic generator of GDP growth and an overly expensive and inefficient bureaucratic state system which, together with legal and administrative complexity and ubiquitous corruption and nepotism, does not encourage or help the implementation of necessary positive processes.

In this, one of the synthetic indicators is the increasing economic migration of human resources, but also the central problem - brain drain as the migration of skilled workers from their native country to a foreign one. Migrations are an old demographic phenomenon and they represent an important category for the analysis of the general state of a country's society. Moving out of economic necessity has its own history and tradition, especially in underdeveloped countries and countries in transition to which it belongs, and Bosnia and Herzegovina is not spared from these processes either.

The departure of the population from Bosnia and Herzegovina according to the time of emigration can be divided into three epochs:

- The period up to before the start of the war (1960-1992), the migration of the population was present exclusively due to the bad economic situation. It is a low-skilled labor force and its key contribution was in the form of remittances
- War period (1992-1995) departure due to war operations. It is done through non-selective emigration where all qualification structures are present

- Post-war period (1995-present), departure due to both the bad economic situation and the long-term unstable political situation. It is mostly a highly qualified labor force and a young population in the prime of life who easily decide to leave.

Although there are no official estimates, the Union for Sustainable Return and Integration of Bosnia and Herzegovina unofficially estimated that 56,987 people left Bosnia and Herzegovina in 2019, 85,000 in 2020, and that number would rise to 170,000 in 2021 [12]. So, it can be said that the annual loss of population is no longer the order of magnitude of a smaller city, but rather a medium-sized city, and if these processes continue, we will be able to say that the population of a large city with a few hundred thousand inhabitants is leaving our country every year. Such a demographic picture of our country warns that this is already a key factor in its development and survival.

The situation becomes more complicated if it is known that the peculiarities of this time in the context of migration are the departure of young and educated people to developed EU countries. Their brain drain has increased as a reflection of changes in global processes, a greater degree of freedom in the flow of people, goods and capital. Simply put, countries like BiH are not able to use their own human potential and the knowledge, skills and abilities they possess due to a series of structural problems, while developed countries have increased their sensitivity towards migration, especially towards highly educated human resources.

An educated workforce participates in this process, where the country of reproduction (in this case, Bosnia and Herzegovina) is completely separated from the host country (developed EU countries). In this context, there is a growing gap between developed and underdeveloped countries because, as is well known, the most qualified people are the basic initiators of economic development. The specific characteristics of the brain drain of our country are:

• The process is increasingly taking on the characteristics of a permanent state
• Demographically, it is accelerating and expanding
• Successful, expert and proven professionals employed in Western European companies, as well as scientists and researchers in various fields whose careers are top notch, do not return to the country and that is why there is currently no significant brain gain..

A lot of research and studies have been done focusing on this issue. In a serious analysis, quality excuses for this state of affairs cannot be found. Tolerance is often associated with:

- Benefits from the diaspora because remittances from abroad are the only source of income for many families in Bosnia and Herzegovina
- Other countries also have this problem
- Going abroad was also present in the former state, planned as temporary but remained permanent.

The central question is what is being done in the country to slow down and reduce the process of brain drain. The institutions of Bosnia and Herzegovina, with the help of the international community, generally recognized the problem of migration, which in addition to the negative natural increase further complicates the situation in the country. But everything remains on the declarative statements of politicians, while very few quality measures have been taken.

Most of the partial measures deal with the employment of young people through employment and self-employment programs under the Employment Agency (e.g. the "Training for the labor market 2023" program, the "Co-financing of self-employment Start up 2023" program, the "Co-financing of employment 2023" program) [13]. Recently, consideration has been given to subsidizing the solution to the housing issue of youth and providing financial support for the education of recognized talents, but all this has been carried out at various local levels without an established comprehensive strategy.

The importance of the diaspora was also recognized, and as one of the steps taken, the Department for the Diaspora was formed at the Ministry of Human Rights and Refugees of Bosnia and Herzegovina. In 2017, the Policy on cooperation with emigration was documented [14] and several projects were launched, such as the Diaspora for Development (D4D) project [15], but their level of success is questionable given that emigration trends have continued and intensified.

Therefore, everything that is speak for and done does not have too much influence on the socio-economic condition of the country. A unique conclusion can be drawn from this: strategically designed changes are necessary. If capital changes of the modern world are added to this, then the demand for them is imposed exponentially. At the same time, it is a great challenge in terms of responsibility. The key concept and its implementation must ensure macroeconomic sustainable and stable development. Establishing a diagnosis is the first, although most important step in solving a given problem. Unfortunately, there is no quick 'shock therapy' for this chronic condition.

4. Strategic development goals, concept and their strong functional connection with the reduction of brain drain

As previously stated, it is necessary to establish a comprehensive strategy from which quality strategic development goals will come out. The strategy should take place simultaneously in two directions:

- Activities within Bosnia and Herzegovina aimed at reducing migration and brain drain and
- Activities directed at the Bosnian-Herzegovinian diaspora in order to start the processes of return to Bosnia and Herzegovina - brain gain, i.e. the return of quality human resources of the diaspora, followed by a significant inflow of financial resources through investments.

The following diagram presents the concept of a comprehensive strategy with all necessary activities:

Figure 3. Conceptual approach to the strategy of socio-economic development.

As can be seen from the presented scheme, not much can be done without political consensus. One of the strategic goals is the reduction of political instability, and this can only be achieved by the recognition by politicians of the consequences of today's migration flows and the understanding that social and economic development is the common denominator of all the inhabitants of Bosnia and Herzegovina. This, along with raising the quality of administration at all levels, certainly improves the business environment, which results in an increase in investments in Bosnia and Herzegovina.

Along with the mentioned activities, an appropriate database must be created, which would contain all relevant data on migration flows, their number, qualification structure, age, reasons for leaving, number of migrants who plan to return from the diaspora. Based on this, quality analysis and monitoring could be done.

It is also necessary to determine the bearers of the implementation of the strategy, because without the right people with the appropriate knowledge, skills and abilities, it will not be successfully implemented, no matter how well it is written. And these activities can be an attractive force for the diaspora, and for the highest quality human resources, to get involved and become key bearers of the positive processes of the country's overall social and economic development.

5. Education as a source of human potential for the creation and implementation of social economic development strategies

By setting up and implementing a strategy of socio-economic development, our country should make a big turn in terms of development. This exposes the essential question of whether there is an appropriate personnel base, especially quality managerial structures for ambitious and demanding changes. In the discourse of that question, we previously absolved the specific phenomenon of our diaspora.

This raises questions about the quality of our education, which are accompanied by many (non)objective controversies. Let's name just a few:

- It is estimated that our education is outdated and far behind the world level of developed countries. At the same time, our professional and scientific personnel are appreciated abroad. On the other hand, the high-quality education provided by developed countries is one of the key reasons for the departure of entire families with the aim of ensuring the highest quality education for their children.
- A large number of private colleges and universities, on the one hand, and uncoordinated and unconnected public educational institutions at the state level, which are insufficiently autonomous and financially dependent on political structures, are a significant present of the narrower / wider picture of the established education system.
- Lagging behind in the pre-war period, with the expansion after the war, a greater coverage of the generation was achieved at all levels of education, but at the same time there was a significant drop in quality requirements. This uncontrolled process, without fulfillment the strict conditions for the opening of higher education institutions in particular, along with other weaknesses, led to a decrease in confidence in the achieved diplomas. The country's demographic situation, together with the accelerated and wider process of emigration, have led school institutions and society to a paradox - the buildings that have been built are empty because there are no children, and then all of this extends beyond secondary schools to colleges.

Faced with this problem, along with constant reasonable criticism of the economy that they have to return vocational high school graduates as well as students to the beginnings of learning, educational institutions launch numerous projects to overcome these weaknesses. Driven by a stronghold in science (DEWEY, FREIRE) where traditionally acquired knowledge cannot be connected with real situations in practice and with the rapid forgetting of what has been learned, the concept of service learning is increasingly being applied as a modern approach to learning that puts students at the center of the educational process [16]. Students are no longer passive recipients of knowledge, but the responsibility for acquiring knowledge is transferred to students through encouraging critical thinking and gaining practical experience in education. One such example is the Faculty of Economics in Bihać, which, with its educations and workshops and the active work of students on specific tasks with the mentoring support of professors, aims to give students the knowledge they need for employment, but which they will be able to use once they start their business careers. Actively participating in solving specific problems, students encounter layered obstacles in implementation that encourage them to think, independently search for new knowledge, creativity, innovation and personal development, gaining experience and references. In addition, students are enabled to understand the purpose of having adequate knowledge, skills and abilities that they acquire while studying, but also their connection to the business environment.

This is just one of the positive examples, but it is indisputable that the education system needs changes and that strategic goal must be a central part of the strategy of social and economic development of Bosnia and Herzegovina.

6. Conclusion

In order to overcome the current situation and trace the path of development, changes are imperative. The modeling of the country's socio-economic development strategy must be approached, in which the brain drain reduction strategy must have a special place and focus. Even the best-designed strategy based on a diagnosed condition will not radically change things if it is not implemented responsibly. For the implementation of the strategy, the necessary prerequisites must be created. That is why the changes must also include the political sphere of the system. Key development decisions must be left to managerial structures, based on knowledge and expertise, freed from bizarre policies that themselves encourage the departure of the most productive part of our population. For the actual implementation of the strategy, a unique acceptance and homogenization of society towards the common good is necessary. This is actually the central theme of this article.

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Normative Activities of the International Labour Organization Regarding Employment at the Global level

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Abstract. Achieving full employment is not and should not be based on a rigid Machiavellian approach, given that, in terms of content, the economic-social dimension of work also includes all other circumstances, i.e. conditions at work and those related to work. This paper will present and analyse two types of ILO resolutions related to the context of achieving (full) employment and employment policies at the global level. Beside short history of the ILO's normative activities, the analysis is focused on normative activities directly related to the goals of poverty reduction and increasing employment, as well as other acts that have an indirect impact on employment.

1. Introduction

A particular expansion of the growth in number of international organizations is noticeable in the period between the two world wars. The regulatory areas, working methods and types of legal acts of these international organizations differ, but it is quite clear that the key role in the context of labour law standards is played by the International Labour Organization (further: ILO), which in its normative activities in the form of conventions and the recommendation regulates the broadest framework related to working conditions. The ILO is also the most massive organization: both in terms of the members' number and in terms of the number of normative acts it has adopted. Since 1919, the problem of unemployment has been one of the priorities in the work of the ILO. Thus, conventions and recommendations represent the most significant instruments regarding the establishment of international labour law standards. In addition to the above, the agreements concluded by the ILO with other organizations and (non)member states with the aim of achieving common international interest in the context of exercising workers' rights are also important, especially those who work abroad or those who are defined as foreigners according to international rules. Such arrangements represent a supplement to the primary normative activities of the ILO and the concretization of basic minimum standards.

This paper will present and analyse two types of ILO resolutions related to the context of achieving (full) employment and employment policies at the global level. The first part of the paper presents a short history of the normative activities of the ILO, i.e. the development of ideas and institutional capacities for (more) comprehensive activities of this organization, the second part of the paper includes those acts that are directly related to the goals of poverty reduction and increasing employment, while the third part of the paper includes other acts that have an indirect impact on employment. In any case, this categorization of the ILO's normative activities has only methodological significance, given that they represent an inseparable unity in the context of choosing an adequate employment policy.

Achieving full employment is not and should not be based on a rigid Machiavellian approach, given that, in terms of content, the economic-social dimension of work also includes all other circumstances, i.e. conditions at work and related to work. Simply put, achieving the goal of full employment must not rely on the violation of workers' rights and freedoms that are guaranteed by international sources of human (and labour) rights. Therefore, this paper represents a compilation of both types of normative activities, which in their totality form an inseparable unity and can only be adequately presented with this approach.

2. General approach

The idea of social justice was the backbone for the formation of the ILO, and although the term social justice acquired different connotations over the years of this organization's operations, it still remained a basic principle in its work [1]. After more than a century of ILO's existence, the role and significance of its normative and institutional activities can be questioned through several different dimensions and periods, but the fact that the ILO is the most significant world organization in the field of labour, which was founded with the aim of realization the idea (read ideal) of social justice. Certainly, the instruments of the ILO are not radical and represent only minimum standards for the protection of the basic rights of workers in each individual state [2]. Thanks to these normative instruments, the ILO continuously improves the quality of the 'world labour law order', especially through the conventions of the General Assembly, which, after being accepted or ratified by the members, represent a universal source of law.

In addition to the traditional preoccupations of the ILO, which are focused on the organization of the workforce, social insurance, professional training of workers, occupational safety and the like, in the last few decades the ILO has been increasingly encroaching on the segment of economic and social relations, given that "social problems are of such a nature that today they present a constant preoccupation of all the institutions of the great UN family" [3]. As the ILO Constitution itself does not limit the competences of this organization, activities are (increasingly) focused precisely on the segment of economic and social relations, among others, and in the context of ways of cooperation and work organization, which has a direct impact on achieving (quality of) employment or 'decent work', which ILO stands for. Thus, the ILO includes the entire segment of work and labour law relations, or only the appropriate segments/categories of work or employees, such as issues of employment, deployment, working conditions, working conditions, content of employment contracts, migration and all other elements that affect seafarers' rights.[1] If the years of adoption of these conventions are analysed in more detail, it is clearly concluded that it is a matter of continuous work of the ILO bodies for over 100 years, which has been adapted to the temporal and spatial context, all with the aim of protecting all or certain categories of workers and ensuring as large and high-quality as possible of employment. As the preamble of the ILO Statute states "prevention of unemployment" as one of the main goals of this organization, the institutional arrangements are also directed towards this goal. Through its normative acts and existing instruments, the ILO prescribes legal frameworks, directs and controls the development of national law and practices of member states.

In order to correctly understand the conventions adopted by the ILO, a preliminary understanding of their legal nature is necessary. Thus, the authors of international conventions generally define them as *sui generis* contracts. This definition also refers to the ILO conventions, thanks to which mentioned organization "expresses and establishes norms on the improvement of labour and social legislation in the world" [4]. Certain systematizations of international agreements divide those according to their formal element, thus, in the field of labour migration, same include two forms: multilateral agreements in the form of ILO conventions and agreements within the framework of the respective regional communities. The first-mentioned international agreements can define the entire matter of labour migration or only its corresponding segments, depending on the agreed multilateral arrangement [5]. If the context of specific regional communities is considered, for example, at the level of the European Union (hereinafter: EU), public policies have been established that encroach on the sphere of national

[1] Among others, these are the following conventions: Convention No. 56 on Sickness Insurance (Sea), Convention No. 91 on Paid Vacations (Seafarers), Convention No. 23 on Repatriation of Seamen, Convention No. 8 on Unemployment Indemnity (Shipwreck).

states' competence, where the following institutions play a key role: the Council of the EU, the European Commission, the European Council, the European Parliament and Court of the EU [6]. Any creation of an "artificial conflict" in the universal sources of law contained in the ILO conventions in relation to the secondary sources of EU law is not desirable at all, given that the subjects of regulation that are covered by their normative activities fall under different segments essential for work, labour relations, working conditions and others [7]. In the end, it is clear that the ILO provides only a normative framework of minimum standards at work, while regional organizations go one step further.

3. Normative arrangements with a direct impact on employment

As previously mentioned, the central part of the work refers to the normative arrangements (acts) of the ILO, which have a direct impact on the employment at the world level. The importance of achieving employment at the global level, as one of the basic strategic goals of the ILO, is best seen in the fact that already on October 29, 1919, immediately after the establishment of the organization itself, Convention No. 2 on Unemployment was adopted. This Convention is a precedent in the context of normative activities of the ILO with the aim of achieving (full) employment at the global level, after which a number of other acts related to this topic were adopted. In this sense, in the further parts of the paper, selected conventions will be presented according to their historical sequence of adoption. Also, emphasis is placed on selected provisions of key conventions and comments on their significance on overall employment in the world, which is related to the issue of (un)employment and employment policy.

3.1. (Un)employment

Shortly after the establishment of the organization, the ILO institutionally endeavoured to minimize unemployment and to eliminate all negative consequences arising from it. In the sense of Convention No. 2 on Unemployment from 1919, states had to undertake overall measures in the fight against unemployment, which includes monitoring, informing and other activities. In the preamble itself, the Convention is identified as a project, which imposes continuous obligations for all countries to which it applies. The Convention was adopted after various proposals "relating to the resources to avoid unemployment and to remedy its consequences" and the states are obliged to submit reports related to unemployment to the ILO within a period that cannot be shorter than three months, including reports on all measures taken in order to "fight against unemployment" [8 – article 1]. In this way, the application of assumed obligations with the aim of suppressing unemployment at national levels is also institutionally monitored. Article 2 of the Convention stipulates the obligation to establish a system of free public employment bureaus, which are under the effective control of the central government. This standard was subsequently elaborated in other normative acts of the ILO.[2] By establishing obligations for those who ratify it, the Convention represents a historical precedent for the institutional action of the ILO in the context of efforts to achieve full employment, leaving at the same time 'free space' for its provisions to be revised or modified in accordance with needs [8 – article 3], which makes it clear that the work of the ILO is not rigid and unchanging, but the exact opposite.

In order to properly understand the importance of the Convention, it is necessary to draw a parallel with the Philadelphia Declaration from 1944, which was the basis for the overall program of achieving (full) employment at the global level in the coming years. The Declaration calls for "full and wider exploitation of the world's productive resources", which consequently supports the economic and social development (read growth) of all countries in the world. In this sense, the importance of full employment as an element for the achievement of economic growth was especially emphasized [9]. The Declaration can rightly be marked as a turning point in the institutional activities of the ILO, considering that in the coming years this organization acted more systematically, practically and efficiently. In addition to the realization of the basic rights to defined working hours and fair income, the standards have meanwhile covered the entire catalogue of rights related to health, pension and social insurance. In its activities, the ILO continuously filled the 'holes' in the constitutions of the member states, where only the right to work

[2] Thus, Convention No. 122 on Employment Policy (1964), which will be discussed separately, stipulates the obligation of each state to choose "methods that are appropriate to the extent appropriate to national conditions", all with the aim of achieving full employment.

was standardized, without establishing a framework for securing work. Therefore, the work is not and must not be a commodity, as foreseen by the principles of the Declaration of Philadelphia. This principle is a guide to the achievement of the highest possible employment at the global level, as one of the goals of the ILO. The standards of Convention No. 158 on Termination of Employment from 1982 confirm that work is not a commodity and that the employment relationship must not be the subject of individual abuses by employers. Termination of employment at the initiative of the employer must be an institutionally regulated category in national legislation and practices, while the ILO clearly prescribes what are the (un)justified reasons for termination of employment [10][3], which clearly prescribes the minimum framework for the protection of employment, i.e. the contractual relationship between employer and employee, which, in relation to normative arrangements that have a one-way effect on the level of employment, has a protective character in relation to what has already been achieved in this sense. This document also regulates other elements that institutionally ensure employment security, such as the prohibition of cancelling the contractual relationship during illness or injury as temporary absences [10 – article 7], the worker's right to defence and the appeal procedure [10 – articles 7-10], notice period [10 – article 11], severance pay [10 – article 12] etc. *Summa summarum*, achieving full employment is certainly the goal of the ILO, but not unconditionally and not at all costs.

3.2. Employment policy

Referring in the preamble to the solemn obligation of the ILO from the Declaration of Philadelphia, which obliges this organization to help in various parts of the world to implement programs that can achieve full employment, as well as the introductory part of the ILO Constitution which foresees "the fight against unemployment and guaranteeing earnings that can provide decent living conditions", and in accordance with the principles of the General Declaration on Human Rights, which regulates the right to work, free choice of work, fair and satisfactory working conditions and protection against unemployment [11 – article 23], ILO's General Conference is dedicated to economic growth and development, raising the standard of living and solving the problem of unemployment. Taking into account the level of economic development and other economic and social goals [12 – article 1, paragraph 2], principles from Convention No. 122 on Employment Policy from 1964 oblige the members to strive for a guarantee of work for all those who want to work, for profitable work in accordance with possibilities, as well as for the existence of free choice of employment and the possibility that workers, without any form of discrimination, to have the opportunity to acquire the necessary qualifications to get a job [12 – article 1, paragraph 1]. The continuous determination and consideration of economic and social policies speaks in favour of the fact that the material from this Convention is timeless and subject to constant examination and certain changes. It is obvious that the echoes of the world economic crisis from the thirties of the 20th century reorganized the work of the ILO, which is best confirmed by the principles of the Philadelphia Declaration and this Convention. The segment of employment policy is covered by Convention No. 131 on Minimum Wage Fixing with Special Reference to Developing Countries, which obliges states to a legally established system of minimum wages [13 - article 1, paragraph 1]. *Vice versa*, the responsible person or persons are criminally liable [13 - article 2, paragraph 1], which proves the efforts aimed at the comprehensive regulation of the employment policy at the global level, but from a different perspective.

As tripartism is the most important characteristic of the institutional organization and activities of the ILO, one of the key segments is the obligation to establish a system of free public services (bureaus) for employment at the national level, which must be under the control of the central government and

[3] Article 5 of the Convention No. 158 on Termination of Employment (1982) explicitly states unjustified reasons for termination of employment, as follows:
a) membership in a trade union or participation in trade union activities outside working hours or, with the consent of the employer, during working hours; b) performing the function of a worker's representative, that is, current or previous performance in that capacity; c) filing a complaint or participating in proceedings against the employer due to his alleged violation of laws or regulations or addressing the competent administrative authorities; d) race, skin colour, gender, marital status, family obligations, pregnancy, religion, political opinion, nationality or social origin; e) absence from work during maternity leave.

reflect the cooperation of the state, workers and employers [14].[4] With this standard, the ILO transfers its way of organization to the national level of the member state. The role of these services is precisely to be coordinators between supply and demand with the aim of achieving as much economic progress as possible, and consequently overall employment at the national level. Public employment services were covered by earlier normative activities, so their work was regulated by Convention No. 34 on Free-charging Employment Agencies from 1933. These earlier normative activities also refer to other conventions and recommendations related to the work of employment agencies, the right to access services for choosing a profession and employment, professional guidance, professional training, and the like. As a result, obligations to provide appropriate and free services with the task of helping migrant workers (a kind of *lex specialis*) are defined in other regulations, as a separate regulation in the field of migration for the purpose of employment.[5] Incidentally, ILO's World Employment Program should be mentioned, which actively supported active policies of national development, in which employment stands out as one of the priorities. Interestingly, whether a coincidence or not, in the same period Germany started with its national program that enabled the employment of economically and health-impaired categories [15], while the ILO receives the Nobel Peace Prize [16].

The importance of open, flexible and complementary systems in general, technical and vocational education, regardless of whether these activities take place within the formal education system or outside it, is recognized in Convention No. 142 on Human Resources Development from 1975, where the member are obliged to adopt and develop "comprehensive and coordinated policies and programs of professional orientation and professional training, closely related to employment, especially through public employment services [17 - article 1, paragraph 1]." States must gradually and continuously expand professional orientation systems, which implies continuous information about the possibility of employment for all those for whom this information is relevant: children, youth and adults, but also handicapped persons and invalids, for whom it is necessary to develop separate appropriate programs [17 - article 3, paragraph 1]. These systems and programs of professional orientation must be related to all sectors of economic activity and at all levels of expertise and responsibility [17 - article 4]. The employment policy of protected categories of employees is regulated in separate documents. Thus, the obligation to implement and revise national policies related to the professional rehabilitation and employment of the disabled is regulated in Article 1 of the Convention No. 159 on the Professional Rehabilitation and Employment of the Disabled from 1983. The aim of these national policies is to equalize opportunities between disabled workers and workers in general, emphasizing separate respect for equal chances, opportunities and treatment for disabled workers [18 – article 4].

It is interesting that the ILO regulates through separate normative activities the rights of certain categories, such as migrants, which means that these acts have the property of *lex specialis* in relation to the above-mentioned documents. Thus, Convention No. 97 on Migration for Employment from 1949 established a normative framework for the protection of all forms of migration for the purpose of employment. Member states are obliged to take appropriate measures to facilitate the departure, travel and reception of migrant workers [19 – article 4], which directly influences the national employment policies for the mentioned category of workers. This Convention incorporates and concretizes previously established standards related to the health and social insurance system, prohibitions of any form of discrimination, the work of employment agencies, the rights of family members of migrant workers, transfer of earnings and everything else that governs the status of migrant workers. Later, after obvious and continuous abuses, the 1975 Convention No. 143 on Migrant Workers (Supplementary Provisions) established a framework for the systematic suppression of clandestine migration and illegal employment of migrant workers. The impact of this Convention on employment policy is reflected in the obligation of member states to take "necessary measures, on the national and international level, in order to establish systematic contacts and exchange information on this issue with other states" [20 – article 4] as well as the clearly defined goal of preventing all abuses of labour trafficking. This

[4] We also refer to Convention No. 88 on Employment Services (1948), where voluntariness is prescribed in the context of using the services of these bureaus, regardless of whether they are public or private services.
[5] We refer to Convention No. 97 on Migration for Employment (1949).

Convention can be identified as a global instrument to combat all possible abuses at work (at the international level), which directly affects general employment. This Convention confirmed the standard that achieving full employment is linked to legal employment - and not any form of (illegal) employment! In addition, the rights of migrant workers have been raised to a higher level, which sends a message that the ILO at the international level wants to establish equally applicable standards for, until then, vulnerable categories of workers.

4. Normative arrangements with an indirect impact on employment

The overall arrangements of the ILO, conditionally speaking, could be divided into the following categories: basic human rights at work and on the occasion of work, employment, social policy, labour management services, industrial relations and participation, working conditions, social security, employment of women, children and youth, old workers, migrant workers, specific areas of employment and others. Respecting the historical sequence of the adoption of conventions, selected conventions that emphasize the principle of equality between men and women, as well as those that regulate the general conditions of employment (work) and those with overall indirect impact on employment at the world level, will be presented in the following part of the paper.

4.1. Equality of men and women

The principle "for equal work - equal pay" is based in the preamble of the ILO Constitution, while the principle of equality is an integral part of the Declaration from Philadelphia [21]. Convention No. 100 from 1951 concretized the mentioned principle from the preamble of the Constitution. The content of the Convention obliges all member states to ensure, using appropriate methods and in the appropriate scope that corresponds to these methods, "the application of the principle of equality of compensation for work of equal value to all workers [22 – article 2, paragraph 1]." The Convention binds the state in terms of the goal, not the implementation mechanism, so the possibility of implementing the stated principle through national legislation, collective agreements and other similar mechanisms or combinations thereof is prescribed [22 – article 2, paragraph 2]. This methodological tool is very reminiscent of the principle of directives and approximation of national rights at the EU level, except that it has an effect on a global level. Furthermore, the addition to the Convention is Recommendation No. 90 on Equal Remuneration, adopted in the same year. This act concretizes the principles of the otherwise very short Convention (with only 8 articles), especially regarding the principle of equal compensation for men and women, when it comes to work of equal value. If the time context of the Convention's adoption is taken into account, the conclusion can simply be drawn that the time of its adoption coincides with the time of the first more credible activities aimed at realizing the equal rights of men and women, which, in the authors' opinion, gives a separate significance to its normative content. We note that, under the auspices of the UN, the Convention on the Elimination of All Forms of Discrimination against Women was adopted only in 1979, and its (optional) Protocol twenty years later, which broadly confirms the principles of the Convention. The indirect impact on employment is reflected in the segment of bringing the labour market closer to women, which motivates this traditionally vulnerable part of the working population. Of course, the achievement of full employment, as one of the basic goals of the ILO, is aimed at the entire working-age population, and not exclusively at men.

In addition to the Convention on Equal Pay, which was previously analyzed, the Convention No. 111 on Discrimination (Employment and Occupation) from 1958 and Convention No. 156 on Workers with Family Responsibilities from 1981 are also important [23]. Convention No. 111 'expands' the protected categories and stipulates that, in addition to gender, the following categories are also protected: race, skin color, religion, political opinion, national or social origin [24 - article 1, paragraph 1, item a].[6] Member States are obliged to undertake appropriate national policies to eliminate all types of discrimination in the context of seeking employment and performing occupations, in accordance with

[6] Convention No. 111 on Discrimination (Employment and Occupation) (1958), Article 1, paragraph 1, item a.

national conditions and customs [24 – articles 2-3]. On the other hand, Convention No. 156, which in its preamble refers to the UN Convention on the Elimination of All Forms of Discrimination against Women, tries to establish a balance between business and private life. In this sense, the national policies of the member states, in relation to persons with family obligations who are employed or want to be employed, must reflect all activities aimed at enabling the realization of that right, without the appearance of any form of discrimination. Also, states are obliged to ensure that, to the extent possible, there is no conflict between the employment of the aforementioned persons and their family obligations [25 – article 3]. The aforementioned principle from the Declaration of Philadelphia, together with the analysed conventions that concretize the principle of equal pay for equal work have an indirect impact on the employment policy at the global level, as well as the level of employment. Achieving full employment is not an unconditional goal, on the contrary. All categories of workers, including those at risk, must participate in the overall work at the global level.

4.2. General conditions of employment

The general conditions of employment are tied to the normative activities of the ILO, which regulate the issues of weekly vacation, paid vacation, annual vacation, paid leave and the like. Thanks to these documents, minimum standards of general working conditions have been established at the global level. In the following part of paper, basic indications will be presented about the acts that regulate paid annual leave and paid leave for educational purposes, although the corpus of labour rights related to the question of leave is regulated by a larger number of ILO conventions and recommendations. Thus, Convention No. 132 on Holidays with Pay defines a number of rights for all employed persons, with the exception of seafarers or other categories of employed persons to whom the provisions cannot be applied due to reasons of an essential nature [26 – article 2], leaving the discretionary right of states to choose the methodology of its application [26 – article 1]. The essential provision defines the obligation of the member state to define (in its legislation) the minimum duration of annual leave, which in any case cannot be shorter than three working weeks for one year of service [26 – article 3]. The minimum length of service to exercise this right must not be less than 6 months, which is accepted as a general standard in national legislation.[7] The obligation of the member states is to ensure that the employee who uses his right to annual leave receives a normal or average salary [26 – article 7, paragraph 1]. Without dwelling separately on the other provisions that regulate the duration and manner of using the right to annual leave, in this, final part of the work, it is expedient to 'touch' on Convention No. 140 on Paid Educational Leave, which obliges member states to create and apply policies in accordance with nationally acceptable methods (and possibly in stages), in order to encourage the approval of paid leave [27 – article 2].[8] These national policies must be aimed at improving professional and functional abilities, as well as improving employment and job security in conditions of economic and technological progress[9], whereby Convention includes standards of both direct and indirect impact on employment at the global level. This document encourages the harmonization of various needs and economic sectors of the member states with the general employment policy, enabling the choice of methodology for the implementation of the framework standards from the document. From the content of Convention, certain hypotheses raised in the paper can be confirmed, which will be separately stated in the conclusion of this paper.

5. Concluding remarks

Based on the above, it must be concluded that the ILO is the most important world organization that establishes frameworks for global employment, working conditions and other labour law standards. In this way, a substantive approximation of national policies, legislative and judicial practices is carried out. By using normative, exegetical and dogmatic methods, the contents of the key ILO's conventions that have a direct and indirect impact on employment were analysed. It was confirmed that this

[7] For the sake of comparison, we refer here to the corresponding provisions of entity labour laws.
[8] The goal is: training at all levels, general, social and civic education, as well as trade union education.
[9] For other national policy standards, check same document, Article 3.

separation of normative acts is important only because of the methodological approach, given that the entire normative activities of the ILO are directed toward both - the greatest possible employment and at the safest and highest work quality. The entire normative arrangements related to the promotion of employment at the global level started in the same year that the organization was founded, which was the result of the fact that the ILO recognized that poverty, wherever it is, presents a danger for everyone. Therefore, the ILO is trying to establish at least approximately equal economic growth of its member states through institutional arrangements, given that an increase in employment in one region or country can ultimately have overall negative consequences for that geographic area as well, if continuous investment is not made in less developed parts of the world. Furthermore, it is impossible to observe in isolation a convention that encourages the harmonization of national policies with the aim of achieving the greatest possible international employment, without bringing into relation with it other standards and principles of the convention that, for example, defines the minimum annual leave. In this regard, the conclusion is that the entire normative activities of the ILO are focused on employment, making this organization a supranational legislator whose standards must be accepted by both member states and other regional organizations that regulate issues at work and on the occasion of work.

Labour is not a commodity, as it was noticed back in 1944, but in the conditions of enormous unemployment, realization of basic rights such as the payment of earned wages is becoming more and more noticeable. Therefore, the normative activities related to achieving full employment are also related to all other standards and principles that regulate issues at work and those related to work. Namely, the assumption of achieving full employment as an ideal is not possible in conditions of abuse of workers' rights. Therefore, in the third part of the work, the appropriate conventions that regulate equality in employment and occupation between men and women were analysed, as well as those that regulate the issues of employment and working conditions. It is clear that, in addition to the economic-social dimension of work, which is the essence of those acts, documents implicitly or explicitly define the goal of achieving as much employment on a global level as possible, which confirms the hypothesis from the introduction of the paper related to (exclusively) methodologically grouped documents in this paper. Achieving full employment is one of the basic goals of the ILO, but not at all costs and not unconditionally. This is the main reason why this organization has survived for over a century, simultaneously participating in global policies to achieve the greatest possible economic growth (and consequently employment) and emphasizing the economic-social dimension of work in its normative and other institutional activities.

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Individual employment contracts – applicable law

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Abstract. An increasing number of working relationships within the European Union whose participants are natural persons who are citizens of different countries, or employment relationships are created, their effects realized or stopped in the territories of different countries, led to the need to work on a gradual realization of a single area of freedom, security and justice, establish the rules by which it is determined the competence of the authorities of a particular jurisdiction and the law that is applicable in disputes between them employees and employers. For this reason, within the European Union, the rules on applicable law are contained in the Rome I regulations. The paper analyzes the provisions of the regulations that refer exclusively to the applicable law for individual employment contracts with regard to the need to protect employees as weaker contacting parties.

1. General

Starting from the European integration process of the 1950 and the conclusion of an agreement establishing three communities, the European Coal and Steel Community,[1] the European Economic Community[2] (further: EEC) and the European Atomic Energy Community,[3] a matter of private international law, is first governed by Article 220[4] of the Treaty of Rome of 25 March 1957.[5] After the

[1] The Treaty on the European Coal and Steel Community was signed in Paris on April 18, 1951, and entered into force on July 25, 1952. (Cf. T. C. Hartley; Osnovi prava Europske zajednice: Uvod u ustavno i upravno pravo Europske zajednice, Magistrat Sarajevo, Sarajevo, 1998, pp. 1-518, pp. 3). (hereafter: Hartley)

[2] The Treaty on the European Economic Community was signed in Rome on March 25, 1957, and entered into force on January 1, 1958. (Cf. Hartley)

[3] The Treaty on the European Atomic Energy Community was signed in Rome on March 25, 1957, and entered into force on January 1, 1958. (Cf. Hartley)

[4] Member States shall, so far as is necessary, enter into negotiations with each other with a view to securing for the benefit of their nationals: - the protection of persons and the enjoyment and protection of rights under the same conditions as those accorded by each State to its own nationals; - the abolition of double taxation within the Community; - the mutual recognition of companies or firms within the meaning of the second paragraph of Article 58, the retention of legal personality in the event of transfer of their seat from one country to another, and the possibility of mergers between companies or firms governed by the laws of different countries; - the simplification of formalities governing the reciprocal recognition and enforcement of judgements of courts or tribunals and of arbitration awards (Article 220).

[5] http://ec.europa.eu/archives/emu_history/documents/treaties/rometreaty2.pdf (8. 6. 2023.).

"*initial lull*"[6] on the basis of Article 220 The Treaty of Rome, for eleven years later continued the development path of European private international law with the adoption of the Brussels Convention on Judicial Jurisdiction and the Enforcement of Judicial Decisions in Civil and Commercial Matters of 27 September 1968[7] (Brussels Convention) and the Rome Convention on the Applicable Law of Contractual Obligations of 19 June 1980[8] (Rome Convention).

These international treaties would later be transformed into sources of European secondary law, the Brussels Convention into Regulation of the European Council No 44/2001 of 22 December 2000 on judicial jurisdiction, recognition and enforcement of decisions in civil and commercial matters,[9] and the Rome Convention in Regulation (EC) No 593/2008 of the European Parliament and of the Council of 17 June 2008 on the law applicable to contractual obligations,[10] and is known as Rome I which is also used in work related disputes.[11]

The subject of this paper is the determination of the applicable law for an individual employment contract under the Rome I Regulation. After the general presentation of the historic emergence of regulations regulating the area of applicable law for a joint employment contract, the autonomy of the will of the contracting parties is exposed, and then only the applicable law. Concluding remarks are made at the very end of the paper.

2. Rome I – *ratione materiae* and *ratione loci*

This Regulation shall enter into force on the 20th day following its publication in the Official Journal of the European Union. It shall apply from 17 December 2009 except for Article 26 which shall apply from 17 June 2009.

This Regulation shall be binding in its entirety and directly applicable in the Member States in accordance with the Treaty establishing the European Community (Article 29). This Regulation shall apply to contracts concluded after 17 December 2009 (Article 28). In accordance with Articles 1 and 2 of the Protocol on the position of Denmark, annexed to the Treaty on European Union and to the Treaty establishing the European Community, Denmark is not taking part in the adoption of this Regulation and is not bound by it or subject to its application (point 46 Preamble).

Structurally contains IV chapters relating to:: CHAPTER I – SCOPE (article 1-2); CHAPTER II – UNIFORM RULES (article 3-18); CHAPTER III – OTHER PROVISIONS (article 19-28); CHAPTER IV – FINAL PROVISIONS (article 29). The substantive scope and the provisions of this Regulation should be consistent with Council Regulation (EC) No 44/ 2001 of 22 December 2000 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters (point 7 Preamble). Any law specified by this Regulation shall be applied whether or not it is the law of a Member State (Article 2). Examining the rule under Article 2, named "Universal application," it is clear that the Rome I Regulation is applicable not only in the EU Member States, but the third party states relevant in the legal dispute.

[6] Jeličić, Božidar: Neki aspekti položaja privatnog prava EU u dosadašnjem razvoju komunitarnog prava, Institut za uporedno pravo, Strani pravni život, br. 2/2011, Publisher, Beograd, 2011., str. 235-252., str. 242.
[7] Official Journal L 299, 31. 12. 1972.
[8] Official Journal C 27, 26. 01. 1998.
[9] Official Journal L 12, 16. 01. 2001.
[10] Official Journal L 177, 4. 7. 2008.
[11] This Regulation shall replace the Rome Convention in the Member States, except as regards the territories of the Member States which fall within the territorial scope of that Convention and to which this Regulation does not apply pursuant to Article 299 of the Treaty (Article 24 paragraf 1). In so far as this Regulation replaces the provisions of the Rome Convention, any reference to that Convention shall be understood as a reference to this Regulation (Article 24 paragraf 2).

This Regulation shall apply, in situations involving a conflict of laws, to contractual obligations in civil and commercial matters. It shall not apply, in particular, to revenue, customs or administrative matters (article 1 paragraph 1).[12]

3. Autonomy of the will

The Rome I Regulation, in accordance with its provisions, regulates the autonomy of the will, i.e. it allows the parties to choose with their will the right that is relevant to an individual employment contract with the aim of protecting the employee as a weaker contracting party in relation to the employer. „ Splitting " of the contract is also allowed, i.e. meaning that for one part of the contract it is the applicable law of one country, and for the other part of the contract the law of another state.[13] Freedom of partial choice of applicable law is an expression of the supremacy of the principle of party autonomy in relation to understanding, especially expressed in continental European private international law, according to which one and the same right should be competent for each legal relationship.[14]

Appreciating the above, the employee has the option of choosing or applying the applicable law of the place where the work is normally performed or applying the applicable law of the country most

[12] The following shall be excluded from the scope of this Regulation: a) questions involving the status or legal capacity of natural persons, without prejudice to Article 13; b) obligations arising out of family relationships and relationships deemed by the law applicable to such relationships to have comparable effects, including maintenance obligations; c) obligations arising out of matrimonial property regimes, property regimes of relationships deemed by the law applicable to such relationships to have comparable effects to marriage, and wills and succession; d) obligations arising under bills of exchange, cheques and promissory notes and other negotiable instruments to the extent that the obligations under such other negotiable instruments arise out of their negotiable character; e) arbitration agreements and agreements on the choice of court; f) questions governed by the law of companies and other bodies, corporate or unincorporated, such as the creation, by registration or otherwise, legal capacity, internal organisation or winding-up of companies and other bodies, corporate or unincorporated, and the personal liability of officers and members as such for the obligations of the company or body; g) the question whether an agent is able to bind a principal, or an organ to bind a company or other body corporate or unincorporated, in relation to a third party; h) the constitution of trusts and the relationship between settlors, trustees and beneficiaries; i) obligations arising out of dealings prior to the conclusion of a contract; j) insurance contracts arising out of operations carried out by organisations other than undertakings referred to in Article 2 of Directive 2002/83/EC of the European Parliament and of the Council of 5 November 2002 concerning life assurance the object of which is to provide benefits for employed or self-employed persons belonging to an undertaking or group of undertakings, or to a trade or group of trades, in the event of death or survival or of discontinuance or curtailment of activity, or of sickness related to work or accidents at work. (Article 1 paragraph 2).

[13] A contract shall be governed by the law chosen by the parties. The choice shall be made expressly or clearly demonstrated by the terms of the contract or the circumstances of the case. By their choice the parties can select the law applicable to the whole or to part only of the contract. The parties may at any time agree to subject the contract to a law other than that which previously governed it, whether as a result of an earlier choice made under this Article or of other provisions of this Regulation. Any change in the law to be applied that is made after the conclusion of the contract shall not prejudice its formal validity under Article 11 or adversely affect the rights of third parties.Where all other elements relevant to the situation at the time of the choice are located in a country other than the country whose law has been chosen, the choice of the parties shall not prejudice the application of provisions of the law of that other country which cannot be derogated from by agreement.Where all other elements relevant to the situation at the time of the choice are located in one or more Member States, the parties' choice of applicable law other than that of a Member State shall not prejudice the application of provisions of Community law, where appropriate as implemented in the Member State of the forum, which cannot be derogated from by agreement. The existence and validity of the consent of the parties as to the choice of the applicable law shall be determined in accordance with the provisions of Articles 10, 11 and 13 (Article 3).

[14] Babić, Davor Adrian: Opće uređenje stranačkog izbora mjerodavnog prava prema uredbi (EZ) 593/2008 o pravu mjerodavnom za ugovorne obveze („Rim i"), Zagrebačka pravna revija, Vol 5., No 3., Zagreb 2016, pp 271-294., pp 288-289.

closely related to the individual employment contract, depending on which law is more favourable for the employer. An individual employment contract shall be governed by the law chosen by the parties in accordance with Article 3. Such a choice of law may not, however, have the result of depriving the employee of the protection afforded to him by provisions that cannot be derogated from by agreement under the law that, in the absence of choice, would have been applicable pursuant to paragraphs 2, 3 and 4 of this Article (Article 8 paragraph 1).

Article 3, paragraph one states: the choice shall be made expressly or clearly demonstrated by the terms of the contract or the circumstances of the case.

4. Applicable law

To the extent that the law applicable to the individual employment contract has not been chosen by the parties, the contract shall be governed by the law of the country in which or, failing that, from which the employee habitually carries out his work in performance of the contract. The country where the work is habitually carried out shall not be deemed to have changed if he is temporarily employed in another country.

Where the law applicable cannot be determined pursuant to paragraph 2, the contract shall be governed by the law of the country where the place of business through which the employee was engaged is situated. Where it appears from the circumstances as a whole that the contract is more closely connected with a country other than that indicated in paragraphs 2 or 3, the law of that other country shall apply (Article 8 paragraphs 2-4).

Furthermore, Articles 10-12 of the Rome I Regulation deal with the question of applicable law as well, namely the Article 10 named Consent and material validity states „The existence and validity of a contract, or of any term of a contract, shall be determined by the law which would govern it under this Regulation if the contract or term were valid. Nevertheless, a party, in order to establish that he did not consent, may rely upon the law of the country in which he has his habitual residence if it appears from the circumstances that it would not be reasonable to determine the effect of his conduct in accordance with the law specified in paragraph 1. "The question of the formality of the validity of the contract is determined by the rule under Article 11, whose paragraph 1 states: A contract concluded between persons who, or whose agents, are in the same country at the time of its conclusion is formally valid if it satisfies the formal requirements of the law which governs it in substance under this Regulation or of the law of the country where it is concluded.[15] Eventually, the rule under Article 12 explains the scope of the law applicable, on whose basis it is determined that the law applicable to a

[15] A contract concluded between persons who, or whose agents, are in different countries at the time of its conclusion is formally valid if it satisfies the formal requirements of the law which governs it in substance under this Regulation, or of the law of either of the countries where either of the parties or their agent is present at the time of conclusion, or of the law of the country where either of the parties had his habitual residence at that time. A unilateral act intended to have legal effect relating to an existing or contemplated contract is formally valid if it satisfies the formal requirements of the law which governs or would govern the contract in substance under this Regulation, or of the law of the country where the act was done, or of the law of the country where the person by whom it was done had his habitual residence at that time. Paragraphs 1, 2 and 3 of this Article shall not apply to contracts that fall within the scope of Article 6. The form of such contracts shall be governed by the law of the country where the consumer has his habitual residence. Notwithstanding paragraphs 1 to 4, a contract the subject matter of which is a right *in rem* in immovable property or a tenancy of immovable property shall be subject to the requirements of form of the law of the country where the property is situated if by that law: (a) those requirements are imposed irrespective of the country where the contract is concluded and irrespective of the law governing the contract; and (b) those requirements cannot be derogated from by agreement (Article 11 paragraphs 1-5). Article 13: in a contract concluded between persons who are in the same country, a natural person who would have capacity under the law of that country may invoke his incapacity resulting from the law of another country, only if the other party to the contract was aware of that incapacity at the time of the conclusion of the contract or was not aware thereof as a result of negligence.

contract by virtue of this Regulation shall govern in particular: interpretation; performance; within the limits of the powers conferred on the court by its procedural law, the consequences of a total or partial breach of obligations, including the assessment of damages in so far as it is governed by rules of law; the various ways of extinguishing obligations, and prescription and limitation of actions; the consequences of nullity of the contract. The way in which the second paragraph of this Article regilates in relation to the manner of performance and the steps to be taken in the event of defective performance, regard shall be had to the law of the country in which performance takes place.

5. Usual work place

On the basis of the Rome I Regulation, the question of the applicable law for a single labor contract, in a situation in which the parties have chosen the applicable law, as well as the situation in which the applicable law cannot be determined, is regulated. Article 8, paragraph 2 of the Rome I Regulation reads: to the extent that the law applicable to the individual employment contract has not been chosen by the parties, the contract shall be governed by the law of the country in which or, failing that, from which the employee habitually carries out his work in performance of the contract.

The country where the work is habitually carried out shall not be deemed to have changed if he is temporarily employed in another country. Therefore, the dirst connecting link for which the juror has decided is the law of the state in which the employer usually conducts its business.

A question of what the usual place of business is arises. Judicial practice gives an answer to this question. The European Court has determined the usual place of business in several cases. In the case C-29/10, *Heiko Koelzsch v État du Grand-Duché* de Luxembourg the court that: Article 6(2)(a) of the Convention on the law applicable to contractual obligations, opened for signature in Rome on 19 June 1980, must be interpreted as meaning that, in a situation in which an employee carries out his activities in more than one Contracting State, the country in which the employee habitually carries out his work in performance of the contract, within the meaning of that provision, is that in which or from which, in the light of all the factors which characterise that activity, the employee performs the greater part of his obligations towards his employer.[16]

6. The place of business in which the employee is employed

The next connecting link in the hierarchical line is the law of the state in which the place of business in which the employee is employer is located. Where the law applicable cannot be determined pursuant to paragraph 2, the contract shall be governed by the law of the country where the place of business through which the employee was engaged is situated (Article 8 paragraph 3).

This situation is more rare in practice in comparison to the aforementioned, but the answer to this question was given by the viewpoint of the European Court, like it had in the case of C-384/10, *Voogsgeerd v Navimer SA*. Namely, European court had a final opinion in this case, stating „1 On a proper construction of Article 6 (2) of the Rome Convention on the law applicable to contractual obligations, opened for signature in Rome on 19 June 1980, the national court seised of the case must first establish whether the employee, in the performance of his contract, habitually carries out his work in any one country, which is that in which or from which, in the light of all the aspects characterising that activity, the employee performs the main part of his duties to his employer. 2 If the national court should take the view that it cannot rule under Article 6 (2) (a) of that convention on the action before it, Article 6 (2) (b) of the Rome Convention must be interpreted as follows: – 'the place of business through which the employee was engaged' must be understood as referring exclusively to the place of business which engaged the employee and not to that with which the employee is connected by his actual employment; – the possession of legal personality does not constitute a requirement that must be met by the place of business of the employer within the meaning of that provision; – the place of business of an undertaking other than that which is formally referred to as the employer, with which that undertaking has connections, may be classified as a 'place of business' within the meaning of

[16] C-29/10, Heiko Koelzsch v État du Grand-Duché de Luxembourg, https://curia.europa.eu / (15. 6. 2023.)

Article 6 (2) (b) of that convention if objective factors make it possible to establish that there exists a real situation different from that which appears from the terms of the contract, even though the authority of the employer has not been formally transferred to that other undertaking."[17]

7. Closest link

And finally, the Rome I Regulation states that where it appears from the circumstances as a whole that the contract is more closely connected with a country other than that indicated in paragraphs 2 or 3, the law of that other country shall apply (Article 8 paragraph 4). On the basis of this Regulation which determines the closest link, it was made possible to apply the law of the closest connection to the dispute in question. For example, in the case of C-64/12, *Anton Schlecker v Melitte Josefe Boedeker,* European Court had a stand point according to which "Article 6(2) of the Convention on the law applicable to contractual obligations, opened for signature in Rome on 19 June 1980, must be interpreted as meaning that, even where an employee carries out the work in performance of the contract habitually, for a lengthy period and without interruption in the same country, the national court may, under the concluding part of that provision, disregard the law of the country where the work is habitually carried out, if it appears from the circumstances as a whole that the contract is more closely connected with another country."[18]

8. Instead of conclusion

In the time of the free movemement of persons, Rome I Regulation significantly improves the position of the employee when choosing the applicable law of a single employment contract. Naimly, the freedom of agreeing on applicable law in a dispute which is a result of a single employment contract, allows both the employer and the employee to determine the applicable law of the dispute in accordance with the Rome I Regulation. The Rome I clearly determines hierarchy of the connecting factors in situations in which the partiea have not chosen the applicable law, as well as, for the protection of the employes, allows that ,for the use of the closest link, the applicable law is the one of the state to which the dispute is most connected, meaning the closest link in the aforementioned usual place of business and the place of business in which the employe is employed. With this rule the Rome I betters employees' position.

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[2] Jeličić, Božidar: Neki aspekti položaja privatnog prava EU u dosadašnjem razvoju komunitarnog prava, Institut za uporedno pravo, Strani pravni život, br. 2/2011, Publisher, Beograd, 2011., pp 235-252.;
[3] T. C. Hartley; Osnovi prava Europske zajednice: Uvod u ustavno i upravno pravo Europske zajednice, Magistrat Sarajevo, Sarajevo, 1998, pp 1-518,
[4] Rome Convention in Regulation (EC) No 593/2008 of the European Parliament and of the Council of 17 June 2008 on the law applicable to contractual obligations;
[5] C-29/10, Heiko Koelzsch v État du Grand-Duché de Luxembourg;
[6] C-384/10, Voogsgeerd v Navimer SA*;*
[7] C-64/12, Anton Schlecker v Melitte Josefe Boedeker*;*
[8] https://curia.europa.eu;
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[17] C-384/10, Voogsgeerd v Navimer SA, https://curia.europa.eu/ (15. 6. 2023.)
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Legal Consequences of Conviction: Review of Legal Solutions in Montenegrin Law

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Abstract. The issue of the legal consequences of convictions is no longer dealt only by lawyers, but also by experts from other social disciplines, which means that the scientific approach to the analysis and study of this segment is increasingly becoming interdisciplinary. Limiting the rights of those convicted *ex lege*, the impact of the legal consequences of conviction extends all the way to full rehabilitation, which actually represents the 'fiction of non-conviction'. In this paper, the author presents and analyzes the legal solutions of the Republic of Montenegro, a modern country whose legislation is more advanced in many segments than other countries of the Western Balkans.

1. Introduction

The legal consequences of conviction, as an institute of criminal law, have recently been the focus of the academic and other professional public. The issue of the legal consequences of convictions is no longer dealt only by lawyers, but also by experts from other social disciplines, which means that the scientific approach to the analysis and study of this segment is increasingly becoming interdisciplinary. They play a very important role in the convict's life after he has been sentenced, especially if the convict has served a prison sentence (or long-term imprisonment). Of course, they also play an important role in other criminal sanctions, whether they are security measures or some other sui generis measures. Limiting the rights of those convicted ex lege, their influence extends all the way to full rehabilitation, which actually represents the 'fiction of non-conviction'. Precisely because of these facts, the legal consequences of a conviction are defined in the literature as civil law sanctions with consequences regarding the loss or prohibition of the certain rights' acquisition, which have their basis in other laws outside the criminal legislation. In the end, no one disputes that the legal consequences of a conviction have a direct or indirect impact on the life of a convicted person, be it in the personal, family, political or some other segment.

In this paper, the author presents and analyzes the legal solutions of the Republic of Montenegro (hereinafter: Montenegro), a modern state whose legislation in many spheres differs from that of other countries of the Western Balkans. In the scope of the Montenegro's criminal legislation, that is the catalog of criminal law regulations, in addition to the Criminal Code, there is also a separate Law on the Liability of Legal Entities for Criminal Offenses, where the legal consequences of conviction are also prescribed. Thus, this paper will analyze and comment on the provisions of both laws that touch on the segment of legal consequences of conviction, rehabilitation and its connection with the consequences of conviction, along with presentation of certain theoretical considerations related to this specific institution of criminal law.

2. General legal framework

In the criminal legislation of modern countries, legal consequences produce effects after conviction for a criminal offense, which means that they have significance not only in a theoretical sense, but also in a practical sense, implying certain limits to the convicted person in his/her daily activities. The theory of criminal law specifically describes the legal consequences of a conviction in the sense that they are 'radioactivity that radiates from the conviction for a long time'. There are several arguments in favor of this definition, of which the nature of the legal consequences of a conviction (restriction of certain rights to a convicted person), their occurrence *ex lege*, as well as their practical application, i.e. their concretization outside of substantive criminal legislation, should certainly be emphasized [1, 2]. [1]

In the positive legal framework of Montenegro, the institution of legal consequences of conviction is elaborated through the substantive criminal law (hereinafter: Law) [3], which established the general framework for the legal regime of the conviction's legal consequences. Basically, they can only be foreseen by law and they take effect by force of the law by which they are foreseen [3 – article 115, paragraph 3]. Identical as in BiH legislation, as well as in the legislation of many other countries, legal consequences may result in the loss of certain rights[2] or the prohibition of acquiring certain rights[3], with a clear provision that they cannot take place when the perpetrator has been sentenced to a fine, suspended sentence, if it is not revoked, a court warning or when the perpetrator has been acquitted of the crime [3 – article 115, paragraph 2]. In this sense, the criminal legislation of Montenegro prescribes and defines the system of legal convictions identically as it was prescribed by the criminal legislation of the SFRY. The only difference is that the Law explicitly defined what was already 'understood', i.e. that the revocation of a suspended sentence and the imposition of a prison sentence can cause legal consequences if another law prescribes the same in the case of the prison sentence's imposition [4]. The Law prescribes that the legal consequences of a conviction occur on the day the judgment becomes final.[4] It is also stipulated that the time spent serving the sentence is not included in the duration of the legal consequences of the conviction.

In the context of other provisions concerning the legal consequences of a conviction, Article 130 of the Law defines that persons covered by the amnesty act, among other things, are given rehabilitation or some or all of the legal consequences of a conviction are abolished. It is also foreseen that by pardoning, as an "individual act of grace" [5], determines a shorter duration of certain legal consequences of a conviction, or some or all of the legal consequences of a conviction are abolished [3 – article 131, paragraph 1]. In addition to the above, the Law also prescribes the content of criminal records, where, in addition to other data, it is prescribed that criminal records contain information on the legal consequences of a conviction. The Law precisely and strictly defines who and under which conditions can access data from criminal records, so it is not necessary to explain in detail the procedural and technical provisions contained in Article 123 of the Law. In terms of the procedural legislation of Montenegro, the Law on Criminal Procedure stipulates only that an application for the termination of the conviction's legal consequences related to the prohibition of the certain rights' acquisition must be submitted to the court that tried in the first instance [6 – article 496].

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[1] This actually creates practical problems, considering that the court is usually not aware of all the number and types of consequences that occur for the convict. This is not the subject of consideration in this paper, but it certainly affects the final evaluation of the institute as very 'difficult'. Therefore, the legal consequences of a conviction are not sanctions, but rather the institute of criminal law.
The legal consequences of a conviction are also called collateral legal consequences, which have their origins in criminal law, but are essentially civil law restrictions.

[2] The Law also prescribes the types of legal consequences of convictions that refer to the termination or loss of certain rights: 1) termination of public functions; 2) termination of employment or termination of a specific vocation or profession; 3) loss of certain permits or approvals granted by the decision of a state body or local self-government body. See Article 116, paragraph 1 of the Law.

[3] These are: 1) prohibition of acquiring certain public functions; 2) prohibition of acquiring a certain title, vocation, occupation or promotion in the service; 3) prohibition of acquiring the rank of military officer; 4) prohibition of obtaining certain permits or approvals granted by decision of state bodies or local self-government bodies. See Article 116, paragraph 2 of the Law.
Note: the legal consequences of a conviction, which consist in the prohibition of acquiring certain rights, can be prescribed for a maximum duration of ten years. See Article 117, paragraph 3 of the Law.

[4] With the stipulation that in the event that after the judgment becomes final, on the basis of which the legal consequences of the conviction occurred, that judgment is amended by an extraordinary legal remedy, the occurrence or further duration of the legal consequences of the conviction is harmonized with the new decision. See Article 117, paragraphs 1 and 2 of the Law.

3. Rehabilitation and legal consequences of conviction

The basic principles in the context of rehabilitation refer to the consequences of a conviction, where it is defined that rehabilitation erases the conviction and ends all its legal consequences, as well as that convicted person is considered unconvicted [3 – article 118, paragraph 1 and article 117, paragraph 5]. The Law makes a distinction between legal and judicial rehabilitation, depending on whether the rehabilitation itself is based on the law or a court conviction [3 – article 118, paragraph 2], without affecting the rights of third parties based on the conviction [3 – article 118, paragraph 3]. Thus, legal rehabilitation is granted only to persons who were not convicted before the conviction to which the rehabilitation refers[5] or who were considered unconvicted by law [3 – article 119, paragraph 1][6], with the exception that it does not arise if the secondary penalty has not yet been executed or if security measures are still in place [3 – article 119, paragraph 3]. Regarding judicial rehabilitation, somewhat stricter rules are defined in Article 120 of the Law[7], with the same rules for execution of secondary punishment and security measures [3 – article 120, paragraph 4], allowing the judge the possibility to (not) grant rehabilitation on the basis of certain subjective and objective parameters.[8] Therefore, both legal and judicial rehabilitation are linked to the legal consequences of conviction. While in the case of legal rehabilitation, the consequences occur according to the law, in judicial rehabilitation, the court, in accordance with the legal provisions, assesses the fulfillment of cumulatively set conditions and makes a decision based on them. It is important to point out that the Law leaves the possibility of rehabilitating persons who have been previously convicted, but only if they can be brought under the framework defined above, i.e. the conditions from Articles 119 and 120, with mandatory fulfillment of the explained objective and subjective criteria.

The legal consequences of a conviction which refer to the prohibition of acquiring a certain right cease within three years from the date of the executed, expired or pardoned sentence, with the condition that such a decision was made by a court.[9] The legislator clarifies the criteria for deciding on the termination of the conviction's legal consequences, where it is prescribed that the court will take into account the behavior of the convicted person after the conviction, whether he compensated for the damage caused by the criminal offense and returned the property benefit acquired committing the criminal offense, as well as other circumstances that indicate on the justification of the legal consequences of the conviction's termination. What is specific about this sub-institute is the necessity of a court decision for the final termination of the legal consequences of a conviction.

4. Liability of legal entities for criminal acts

In contrast to, for example, the criminal legislation of BiH, the Law on Liability of Legal Entities for Criminal Offenses (further: Law on Legal Entities) [7], in addition to the Law, it is an integral part of the Montenegro's criminal legislation catalog that treat and regulate the legal consequences of conviction, with the fact that the Law on Legal Entities, as can be inferred from the name itself, 'covers'

[5] Previous non-conviction as an explicit condition for rehabilitation still causes many discussions.

[6] In the following paragraph, the Law stipulates that rehabilitation occurs if: 1) a person who has been declared guilty and acquitted of punishment or who has been given a court warning, does not commit a new criminal offense within one year of the finality of the verdict; 2) a person who has been given a suspended sentence does not commit a new criminal offense at the time of verification and within one year after the expiration of the verification period; 3) a person who has been sentenced to a fine, community service or prison sentence of up to six months does not commit a new criminal offense within three years from the date on which the sentence was executed, expired or pardoned; 4) a person who has been sentenced to a prison sentence of more than six months to one year does not commit a new criminal offense within five years from the day when that sentence was executed, expired or pardoned.

[7] Those rules imply that rehabilitation can be granted to a person who has been sentenced to a prison sentence of more than one to two years, if he/she does not commit a new criminal offense within five years from the day the sentence was executed, expired or pardoned (paragraph 1). For persons sentenced to imprisonment for more than two to three years, judicial rehabilitation can be granted if they do not commit a new criminal offense within eight years from the day when the sentence was executed, expired or pardoned (paragraph 2).

[8] The subjective parameter refers to the judge's discretionary right to grant rehabilitation if he/she finds that the convicted person deserved the same by his/her behavior. The objective parameter refers to the possibly already compensated damage (according to his capabilities), while leaving the general standard that the court is obliged to take into account all other circumstances of importance for granting rehabilitation, especially the nature and significance of the act. See Article 120, paragraph 3 of the Law.

[9] Unless, of course, the legal consequences of the conviction have not already ended due to rehabilitation. See Article 122, paragraph 1 of the Law.

only legal entities.[10] In the Law on Legal Entities, a legal entity is defined as "a business company, foreign company and part of a foreign company, public company, public institution, domestic and foreign non-governmental organization, investment fund, other fund (except for a fund that exclusively exercises public powers), sports organization, political party, as well as another association or organization that, within the scope of its business, constantly or occasionally generates or acquires funds and disposes of them".[11] Thus, Montenegro falls under the examples of countries that "reflect a comprehensive international trend" [8], given that the definition of a legal entity does not exclude subjects from certain sectors due to their special status: non-governmental organizations, media companies or political parties [8].[12]

The Law on Legal Entities, in accordance with the differentiation also recognized in the Law, recognizes the sub-institutions of termination (prohibition of carrying out activities on the basis of a permit, license, authorization or concession issued by state authorities) and loss of certain rights (prohibition of obtaining a permit, license, authorization or concession issued by state authorities) [7 – article 33, paragraph 1]. It is prescribed that the legal consequences of a conviction for a legal entity appear on the day of the finality of the judgment which imposed a fine (i.e. money fine or mulct), which presupposes the imposition of a fine on the legal entity. Thus, a fine is the basic punishment, while the legal consequences of a conviction are the loss of certain rights that 'extend' from the criminal offense itself, with a maximum duration of 10 years [7 – article 33, paragraph 2]. The 'legal life' of a legal entity after a conviction is certainly largely based on the legal consequences of the conviction and the separation of this segment of criminal law legislation into a separate law definitely brings with it certain advantages compared to the conventional approach. If we were to ignore all the other advantages of this institute, it would be enough to mention that this pragmatic separation made the work of judges who decide in criminal cases easier.

Just as in the Law, the Law on Legal Entities defines that rehabilitation erases the conviction and ends all its legal consequences, as well as the convicted legal entity is considered unconvicted without affecting the rights of third parties who base the same on the verdict itself [7 – article 37].[13] Article 41, paragraph 1 of the Law on Legal Entities stipulates that when three years have passed from the date of the executed, expired or pardoned sentence, the court may decide to end the legal consequences of the conviction related to the prohibition of acquiring a certain right, if it has not already ended as a result of rehabilitation. The next paragraph provides solutions similar to those in the Law, and these refer to specific subjective (behavior of a convicted legal entity after conviction), objective (compensation for damages and return of acquired illegal property benefits) and other circumstances that justify the termination of the conviction's legal consequences and which in any case is appreciated by the court that makes a meritorious decision. Similar solutions in the aforementioned laws dealing with the legal consequences of a conviction are also found regarding the provision of data from criminal records, except that the Law on Legal Entities stipulates that the Central Register containing this data is managed by the Commercial Court.

[10] Moreover, the Law stipulates in Article 31 that the liability of legal entities for criminal acts, as well as sanctions, will be provided by law, while the Law on Legal Entities in Article 1 confirms this, thus synchronizing these two laws.

[11] Of course, at the very beginning of the Law, it was defined that the state, state bodies and local self-government bodies, as well as the legal entity entrusted by law with the exercise of public powers, are not responsible for criminal acts. See Article 4, paragraph 1 and the link with Article 2, paragraph 1 of the Law on Legal Entities.

[12] In this document, it is mentioned that it is desirable to include the above-mentioned legal entities in the liability system while „taking into account higher threshold values or exemptions when it comes to certain sanctions such as liquidation". Extending the scope of responsibility to entities that do not have legal personality certainly gives prosecutors more space for flexible action. Finally, in accordance with the practice of German courts, it is understood that the term legal entities also includes foreign legal entities.

[13] The following two articles also explain the types of rehabilitation, just as it was done in the Law: Thus, legal rehabilitation is granted only to a legal entity that was not convicted prior to the conviction to which the rehabilitation applies or that is considered unconvicted by law, and occurs if: 1) a legal entity that has been declared guilty and acquitted does not commit a new criminal offense within a year after the verdict becomes final; 2) a legal person who has been given a suspended sentence at the time of verification does not commit a new criminal offense within one year after the expiry of the verification period; 3) a legal entity that has been sentenced to a fine in the amount of up to five thousand euros does not commit a new criminal offense within three years from the day when that sentence was executed, expired or forgiven.
On the other hand, judicial rehabilitation can be granted to a legal entity that has been sentenced to a fine of more than five thousand euros, if it does not commit a new criminal offense within five years from the date on which the sentence was executed, expired or forgiven. This is prescribed with specific objective and subjective conditions, similar to the Law.

5. Conclusion

Interdisciplinarity - as a way of approaching the problem, has recently become a basic characteristic of the analysis of the convictions' legal consequences, which play an important role in all criminal sanctions. The life of a convicted person (whether legal or physical) is largely based on restrictions imposed by partial or complete sanctions of certain rights that are incorporated by the legal consequences of conviction. This is exactly the reason why domestic and international experts of various academic and professional profiles deal with this topic.

With minor differences explained in this paper, it is concluded that the general legal regime of the convictions' legal consequences is almost identical to the one that existed in the SFRY. The general framework for the legal regime of the conviction's legal consequences is established by the Criminal Code, while, for pragmatic and opportune reasons, the convictions' legal consequences for legal entities are treated separately through the Law on Liability of Legal Entities for Criminal Offenses, which, although it is unlikely that the European Union explicitly requires this from the Western Balkans countries, has established a modern pro-European legislative framework with a comprehensive definition of legal entities, which in practice leaves very little space for manipulations and abuses.

The 'radioactivity' of the convictions' legal consequences can also be felt in the criminal legislation of Montenegro, taking into account the legal solutions provided for in both laws. Although very similar in the context of institutional solutions, the aforementioned two laws completely separate the responsibility of legal and natural persons, which is certainly a more purposeful and rational solution. Also, both laws recognize the sub-institutes of loss and prohibition of certain rights' acquisition, which is a present solution in the legislation of other countries in the region. It is concluded that the criminal legislation of Montenegro, with regard to the regulation of the convictions' legal consequences, experienced a kind of positive transformation fifteen years ago, which brought it closer to European standards in this area.

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[8] Council of Europe 2020 *Liability of legal entities for criminal acts of corruption* – Strasbourg, p 86

Working from home – way to heaven or road to hell

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Abstract. Working from home became popular in the past few years due to the "lockdown" and measures of social distancing caused by the Covid-19 pandemic. After the pandemic such a way of working transformed into one of the legally regulated ways of work. Working from home exposes employers to additional obligations and duties toward the employees. This way of working is only possible to perform with jobs with low risks. On the other hand, such a way of work causes also changes in employee's lifestyle, and can also cause additional stress, especially due to additional or irregular working hours. This study aims to assess the perceptions of workers from the public and private sectors about working from home. The survey was conducted with a questionnaire and it was found that working from home can be an appropriate way of working if employers oblige to their additional duties and if the employees set strict boundaries between working hours and private life.

1. Introduction

The phenomenon of remote work was already considered in the 1980s since an increasing number of occupations require only such tools as a phone and a computer or laptop with Internet access. [1] The question arises whether working from home could replace traditional offices. For some working positions, that will probably be the case.

In the conditions of the COVID-19 pandemic, the level of social interaction was reduced to the minimum possible since social interaction increased health risks. In those circumstances, working from home proved to be a desirable, convenient, and appropriate form of working, especially in situations where, due to restrictions and anti-Covid measures, other forms of working were not allowed or possible. [2]

With the coronavirus crisis, many companies and institutions had to change to e-work and home offices. Suddenly and unexpectedly, this has become the solution, even for those who hesitated about its implementation or were not wholly persuaded about the positive features of this kind of work. [3], [4]

After the situation normalized, the legislator in Croatia reached for additional regulation of the working from home institute, aiming to make this a regular form of working since many employers and workers saw the advantages of such a way of working. Disadvantages, on the other hand, are yet to be considered.

Additionally, Government of the Republic of Croatia plans to meet the goal of having 20% of civil servants in the hybrid work model by the end of 2023. [5]

The paper takes into consideration not only the advantages in the form of cost optimization and greater efficiency but also the potential risks for the welfare of workers of such a form of work, with an emphasis on the possible need to adapt private life to work conditions, mixing work with the private lives of workers and their families, as well as the potential stress caused by the organization of working hours. When there is a physical separation of the workplace and the time of performing work tasks from the family home and free time, it is easier to set and maintain boundaries between business and private

life, although often many employees even then "carry work at home" in the form of stress that is projected on their health and interpersonal relations. In conditions where the workplace and the family home intertwine, it is much more difficult to set and maintain these boundaries.

2. Legal regulation of working from home in the Republic of Croatia

Amendments to the Labor Law in 2022 ("Official Gazette" No. 151/22): amended Article 17 and new Articles 17.a to 17.c of the Labor Law ("Official Gazette" 93/14, 127/17, 98/19, 151/22, 64/23; further: Labor Law) regulates the way of working outside the employer's premises, which can be organized in two different forms: work at a separate workplace and remote work. [6]

Work at a separate place of work is work in which the worker performs work from home or in another space of similar purpose, which is determined based on the agreement between the worker and the employer and which is not the employer's premises. The place of work is not the employer's premises, and this specific place is determined by the contract.

Remote work is work that is always carried out through information and communication technology, where the employer and the worker agree on the right of the worker to independently determine the place where he will perform this work, which can be variable and depend on the will of the worker. Consequently, such work is treated differently in the sense of regulations on occupational safety. Such a working place is not considered work at the place of work, i.e., at a separate place of work, when regulating occupational safety.

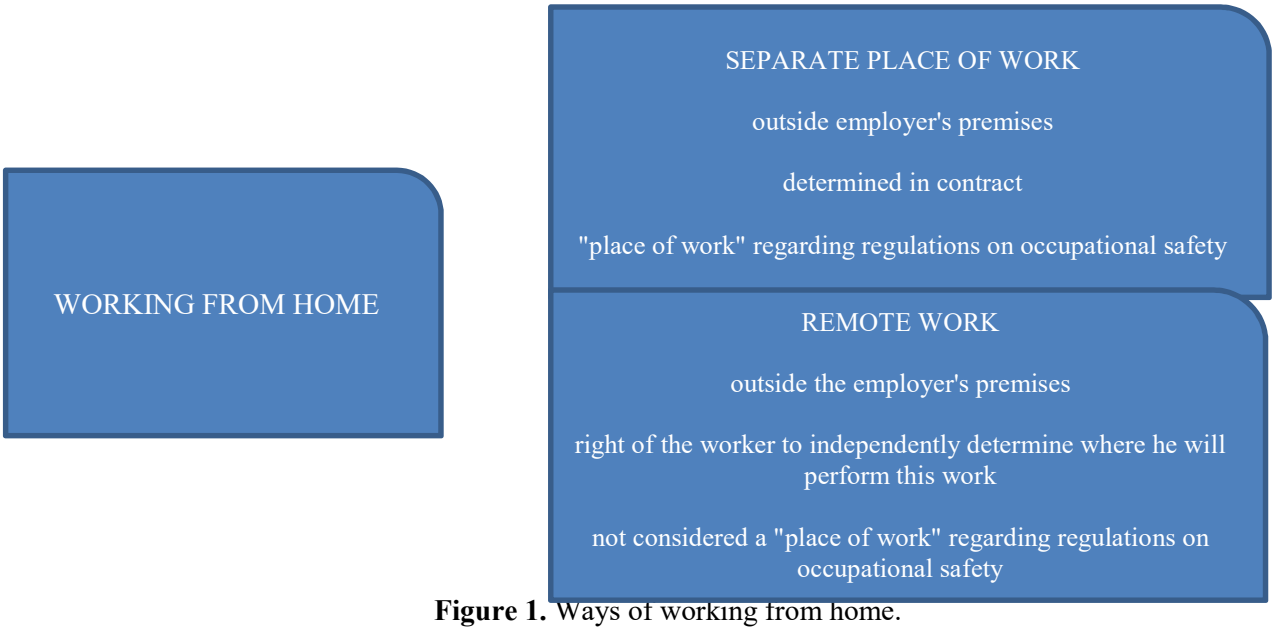

Figure 1. Ways of working from home.

2.1. Common provisions

2.1.1. Scope of application and voluntariness. However, jobs that are defined by Labour Law or another law as jobs with special working conditions, i.e., jobs where, even with the application of health and safety protection measures at work, it is not possible to protect the worker from harmful effects, may not be performed in this way.

For both types of work, it is prescribed that they can be performed as permanent, temporary, or occasional if, at the suggestion of the worker or the employer, the worker and the employer agree on such a type of work.

As a rule, working from home is voluntary, resulting from the mutual will of the worker and the employer.

The law regulates two exceptions in the case:

1. In the case of extraordinary circumstances resulting from an epidemic disease, earthquake, flood, environmental incident, or similar phenomena, the employer may, in order to continue business and protect the health and safety of workers and other persons without changing the employment contract with the worker, agree to work at a separate workplace. For such work, if it lasts longer than 30 days starting from the day of the occurrence of the extraordinary circumstance, the employer is obliged to offer the worker an employment contract with the mandatory content of the employment contract in the case of work at a separate workplace. The purpose of this regulation is to make it possible for the employer to organize work and maintain the working process in the case of extraordinary circumstances, such as the pandemic.
2. An employee who works on the employer's premises, in order to harmonize work and family obligations and personal needs, can request the employer amend the employment contract to require the employee to work at a separate workplace for a certain period of time in the case of:

- health protection due to a diagnosed illness or established disability
- pregnancy or parental obligations towards children up to the age of eight
- provision of personal care that, due to serious health reasons, is needed by a member of the immediate family or is needed by a person living in the same household as the worker.

The employer is not obliged to comply with the request but is obliged to consider it, taking into account the needs of the worker and the needs of the work organization, and in case of rejection or its adoption with a delayed start of application, he is obliged to the worker within a reasonable time and no later than within 15 days from the date of submission of the request, submit a reasoned written answer. During this agreement, even before the deadline, the worker can ask to change the contract and perform the work again at the employer's premises.

2.1.2. Employee's rights. The provisions of the Labor Act on the schedule of working hours, overtime work, redistribution of working hours, night work, and breaks are applied to the contract for work at a separate workplace and to the contract for remote work, unless otherwise regulated by the Labor Act, a special regulation, a collective agreement, an agreement concluded between the works council and the employer, or an employment contract.

Salary and other material rights of workers who work at a separate place of work or work remotely must not be set at a lower amount than the salary of workers who work in the employer's premises on the same or similar jobs, nor may their other rights from the employment relationship or in connection with the employment relationship that the worker achieves be determined to a lesser extent than that determined for the worker who works in the employer's premises on the same or similar jobs.

It is also regulated that when determining in more detail the method of performing work at a separate work place or remotely, the employer is obliged to adjust the amount and deadlines for the execution of work in a way that does not deny the employee the right to daily, weekly, and annual leave within the established scope.

2.2. Distinguishing provisions

2.2.1. Working at a separate workplace. Labor Law stipulates the mandatory content of the employment contract in the case of work at a separate workplace, so such a contract must contain additional information on:

- the organization of work that enables the availability of workers and their unhindered access to the business premises and to information and professional communication with other workers and the employer, as well as third parties in the business process.
- method of recording working hours
- means of work for the performance of work that the employer is obliged to acquire, install, and maintain, i.e., the use of the worker's own means of work, if he uses them, and reimbursement of related costs
- compensation for expenses incurred due to the performance of the work, which the employer is obliged to compensate the worker if the work is contracted as permanent or when the work

period during one calendar month lasts longer than seven working days, unless a more favorable agreement has been made in the collective agreement or employment contract.
- the method of exercising the right to employee participation in decision-making, just as for other employees of that employer
- the duration of the work, i.e., the method of determining the duration of such work.

According to Labor Law, the employer is obliged to compensate the worker who works at a separate workplace for expenses incurred due to the performance of the work if the work is contracted as permanent or when the work period during one calendar month lasts longer than seven working days, in the amount determined by the collective agreement or employment contract.

The employer has the right to enter the premises of the worker's home or any other premises that are not the premises of the employer for the purpose of maintaining equipment or carrying out predetermined supervision related to the working conditions of the worker if this is agreed upon between the worker and the employer and only at the time agreed upon with the worker. From the publicly published opinions of the Ministry of Economy, Labor, and Entrepreneurship, the worker, even though he works in a separate place, must not be prevented from, for example, accessing the employer's business premises to take over documentation, printing, scanning, etc.; that is, he must not be prevented from, for example, coming to a business meeting live, etc.

The employer is obliged to ensure the protection of the privacy of the worker who works in a separate workplace and to ensure work in a safe manner and in a manner that does not endanger the safety and health of the worker when, according to the nature of the work and the magnitude of the risk to the life and health of the worker assessed in accordance with the regulations on occupational safety at a separate workplace, it is possible.

An employee who works at a separate workplace is obliged to comply with safety and health measures in accordance with special regulations.

2.2.2. Working remote. When working remote, the contract must contain additional information: about the employee's right to freely determine where he will perform his work and about the work organization that enables the availability of the employee and his unhindered access to the business premises as well as information and professional communication with other employees and the employer, as well as third parties in the business process. [6]

But the contract must contain:
- the organization of work that enables the availability of workers and their unhindered access to the business premises and to information and professional communication with other workers and the employer, as well as third parties in the business process
- method of recording working hours
- the method of exercising the right to employee participation in decision-making, just as for other employees of that employer
- the duration of the work, i.e. the method of determining the duration of such work.

Notably, provisions about means of work for the performance of work that the employer is obliged to acquire, install and maintain, i.e. the use of the worker's own means of work, if he uses them, and reimbursement of related costs and compensation for expenses incurred due to the performance of the work are optional, so the contractual parties can agree upon them, or agree that this is not necessary.

2.2.3. Differentiation. In terms of safety at work, there is a difference between working at a separate workplace and working remotely.

Namely, in the case of remote work, the place of work is considered to be the place of work that is under the direct or indirect supervision of the employer, and as remote work is variable and depends on the will of the worker which in certain circumstances, can also take place in conditions that the employer cannot influence, remote work is not considered work at the workplace in terms of occupational safety regulations.

Table 1. Comparison of contractual provision (source: own source).

Provisions in the contract	Working in a separate work place	Remote work
employee's right to freely determine where he will perform his work	non-applicable, contract determines place of work	obligatory
availability of workers and their unhindered access to the business premises	obligatory	obligatory
availability of workers access to information and professional communication in the business process	obligatory	obligatory
method of recording working hours	obligatory	obligatory
acquiring, installing and maintaining means of work i.e., the use of the worker's own means of work, reimbursement of related costs	obligatory	optional
compensation for expenses incurred due to the performance of the work	obligatory (when permanent or longer than seven working days during one calendar month lasts), amount determined by the collective agreement or employment contract	optional
the method of exercising the right to employee participation in decision-making	obligatory	obligatory
duration of the work, i.e., the method of determining the duration of such work.	obligatory	obligatory
ensure the protection of the privacy of the worker who works in a separate workplace.	obligatory	obligatory
ensure work in a safe manner and in a manner that does not endanger the safety and health of the worker	obligatory, may include an inspection or other ways to confirm appropriate suitability	not considered "places of work," obliged to provide with written instructions
institute for training workers to work in a safe way	obligatory	cannot be applied entirety (monitoring and the assessment of practical skills excluded)
an employee who works at a separate workplace is obliged to comply with safety and health measures in accordance with special regulations.	obligatory	obligatory
employer's right to enter worker's home or other premises for the purpose of maintaining equipment or supervision of working conditions	obligatory, previously agreed and only at the agreed time	non-applicable; not a "place of work."
regulations on occupational safety related to evacuation, rescue, and providing first aid	non-applicable, provisions are applied appropriately	non-applicable; not a "place of work."

3. Advantages and disadvantages of working from home

3.1. National recovery and resilience plan

As part of the National Recovery and Resilience Plan 2021-2026, a hybrid model of work is being introduced into state bodies, according to which the Government of the Republic of Croatia, as part of the National Recovery and Resilience Plan 2021-2026, plans to meet the goal of having 20% of civil servants in the hybrid work model and 60% of civil servants educated for the application of the hybrid work model ("Smart Working") by the end of 2023. [5]

Arguments cited in support of the introduction of work from home are:

- contribution to digitization and the improvement of the quality of public administration,

- welfare of officials,
- reduction of the ecological footprint and material costs,
- strengthening of competencies and
- better balance between business and private life.

3.2. The most commonly observed advantages and disadvantages in literature

Among the most commonly observed advantages and disadvantages in literature [7] are shown in Table 2.

Table 2. The most commonly observed advantages and disadvantages. (source: own creation)

ADVANTAGES	DISADVANTAGES
flexibility	isolation
productivity, efficiency	conflicts
satisfaction	technical difficulties, hardware, security
work-living balance	stress, depression
less commuting	over-time, workaholism, burnout
cost reduction	culture, family background
eco-friendly	uncertain legal environment and career
image, morality, and concentration	reduction in turnover
employment, acquisition, and retention	team work

4. Methods

The survey was conducted in the period from June 1st to June 10th, 2023. The aim of this study was to collect and analyse the perceptions of employees from the public and private sectors about working from home. The survey was conducted with an online questionnaire. The survey included 24 questions which can be classified into several categories. First category of questions (1 to 4) included general information about responders (gender, age, sector in which they work, qualifications). Second category (5 to 6) were questions about the period of working from home and about with whom they live in the household. Third category (7 to 16) were questions about safe working from home, remodelling or additionally furnishing the workplace at home, also question did the employer provide the necessary work equipment for working from home, or does the employer bear costs such as electricity, heating, internet, telephone and other costs related to utilities, and also the question how did work from home started. Then questions about working hours, and also about the way they dressed while working from home, and about maintaining contact with co-workers, about safety at work. The fourth category (17 to 18) were questions related to advantages and disadvantages of working from home. Fifth category (19 to 22) were questions in which responders had to access to what extent, on a scale from 1 to 5, working from home affected on stress, vacation, efficiency, influence on the life habits of them and their household members. Last two questions were about the necessary conditions for work and concentration when working from home and what would the responders change about the working from home.

5. Results and discussion

In the survey participated 100 workers from Croatia, of which 71 were females (71%) and 29 were males (29%). Most of the responders are up to 35 years (52%) and 62% of responders which work in public sector have a master's degree, while 66% of responders which work in private sector have also a master's degree.

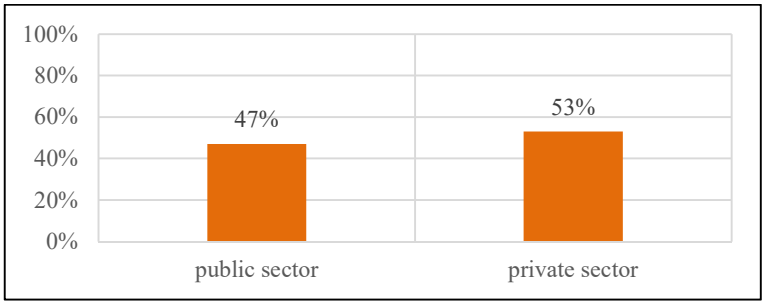

Figure 2. Distribution of responses to the question in which sector the work.

According to Figure 2, working from home is equally widespread in the public (47%) and private sectors (53%). Working from home appears both for shorter and longer durations, with longer durations being more widespread in the private sector (58%) than the public sector (28%), as shown in Figure 3.

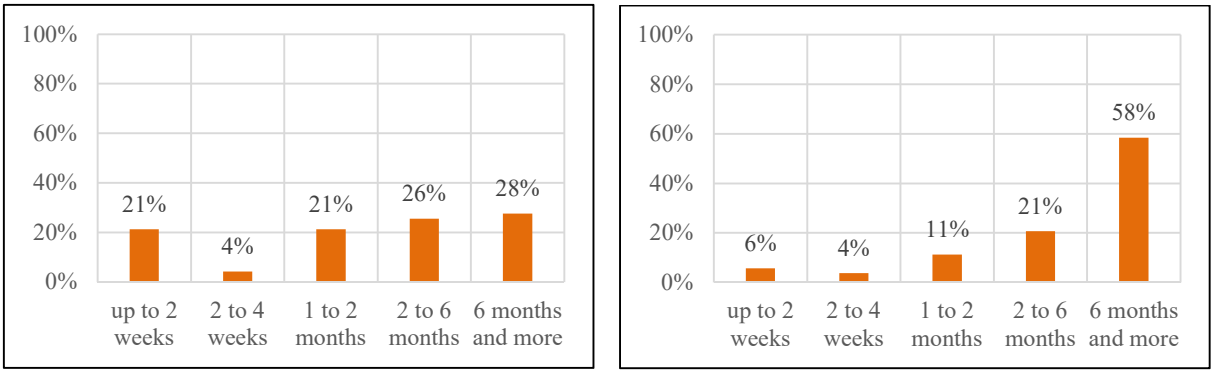

Figure 3. Distribution of responses to the question about period of working from home in public sector (left) and private sector (right).

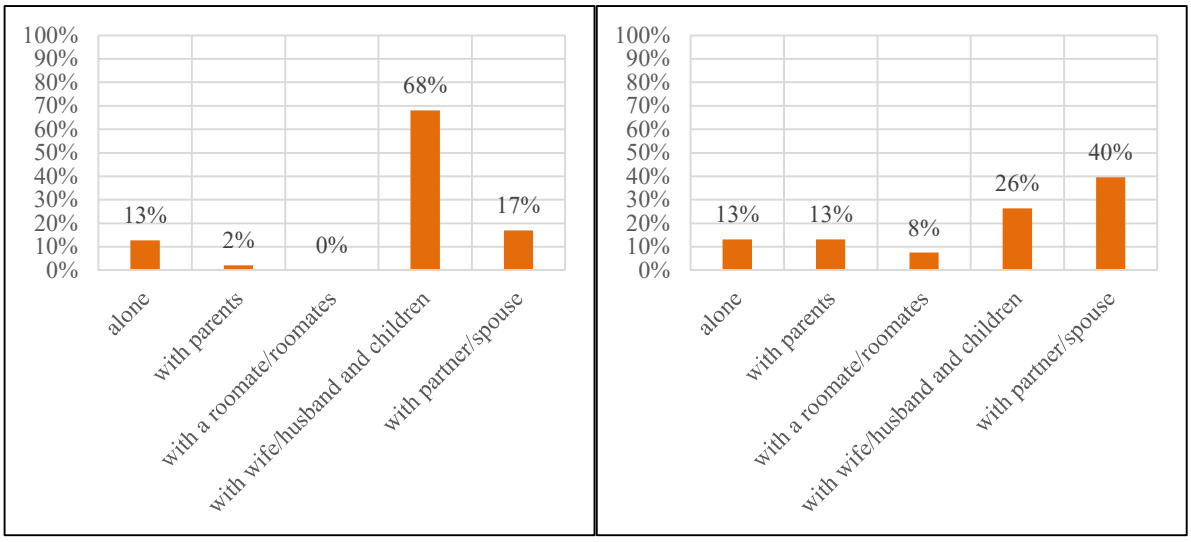

Figure 4. Distribution of responses to the question about with whom they live in the household in public sector (left) and private sector (right).

As shown in Figure 4, most of responders from public sector live with their wife/husband and children (68%), while most of responders from private sector live with partner/spouse (40%). According to Figure 5, the majority of workers (72%) from private sector have secured space in their home for safe

working, while 53% of workers from public sector do not have adequate space for safe working from home.

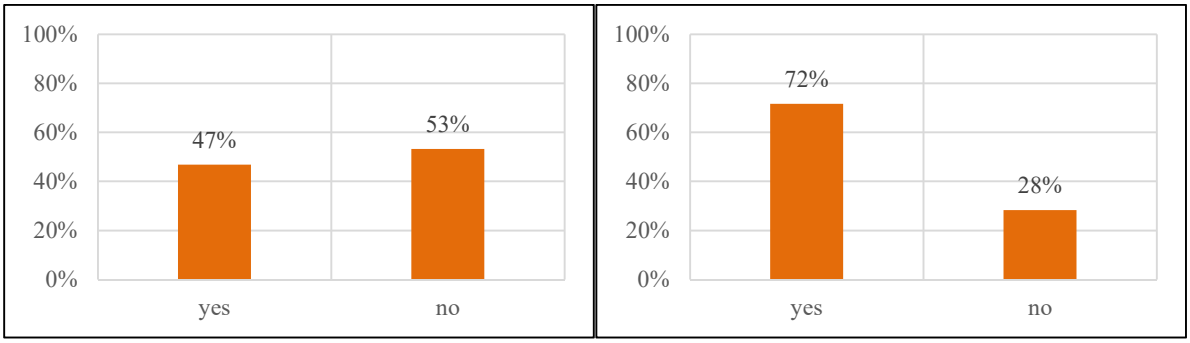

Figure 5. Distribution of responses to the question about secured space in their house/apartment for safe work from home in public sector (left) and private sector (right).

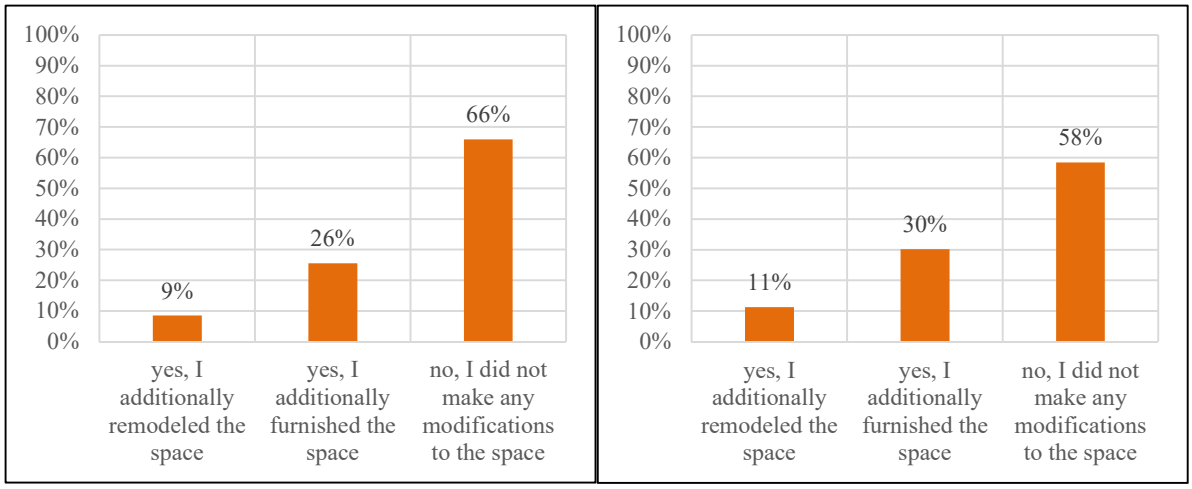

Figure 6. Distribution of responses to the question, did they have to reorganize or additionally furnish their home due to working from home in public sector (left) and private sector (right).

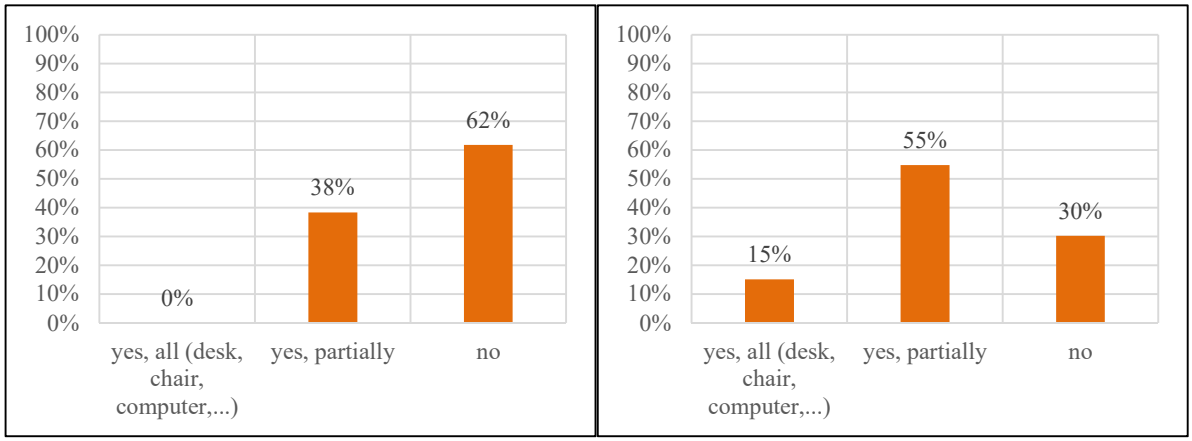

Figure 7. Distribution of responses to the question, did the employer provide the necessary work equipment for working from home in public sector (left) and private sector (right).

According to Figure 6 and Figure 7, the majority did not remodel or additionally equip the place of work (66% public, 58% private); the employer did not provide mobile working equipment at all (62% public, 30% private) or provided it only partially (38% public, 55% private). It is significant that in the

public sector, no one provided all the equipment, e.g., desk, computer chair, etc., and only 15% of private employers provided all the equipment.

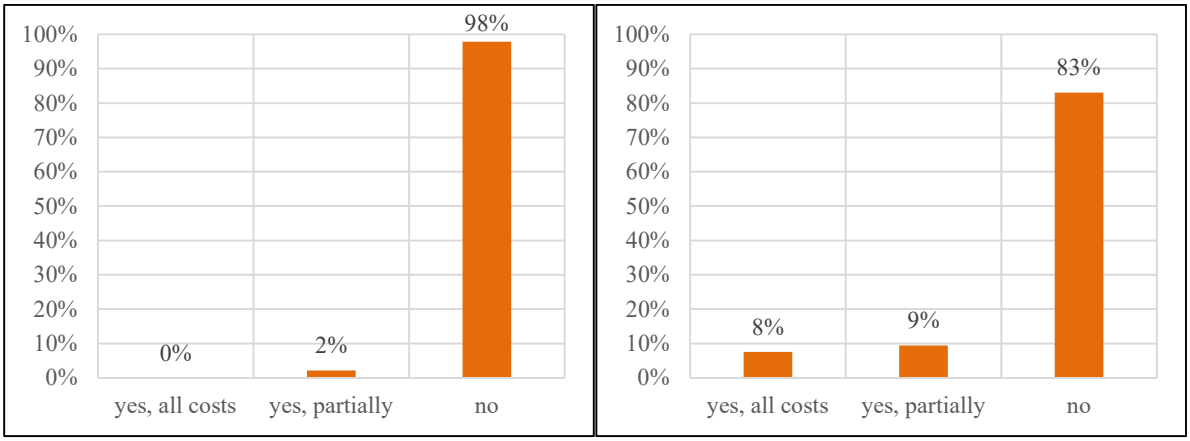

Figure 8. Distribution of responses to the question, does the employer bear costs such as electricity, heating, internet, telephone and other costs related to utilities in public sector (left) and private sector (right).

From the distribution in Figure 8, it can be seen that the employer did not bear the costs in public sector at all in 98% cases, 2% partially, and in private sector did not bear the costs in 83%, partially in 9%, all in 8% cases.

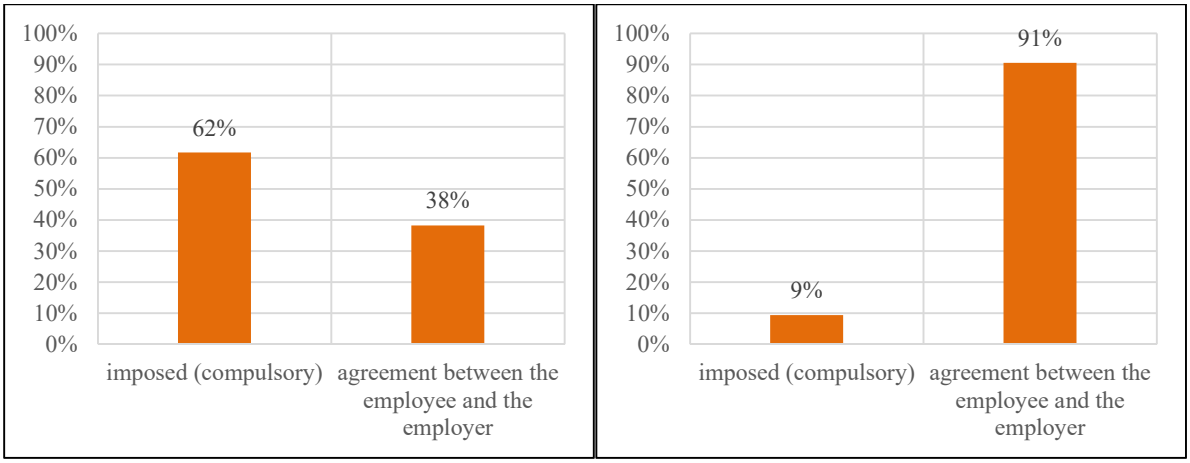

Figure 9. Distribution of responses to the question how did working from home started in public sector (left) and private sector (right).

According to Figure 9, working from home was primarily compulsory (due to outstanding circumstances) in the public sector (62%); secondarily, this was agreed upon (38%). In private sector it was 91% agreed upon, only 9% was compulsory.

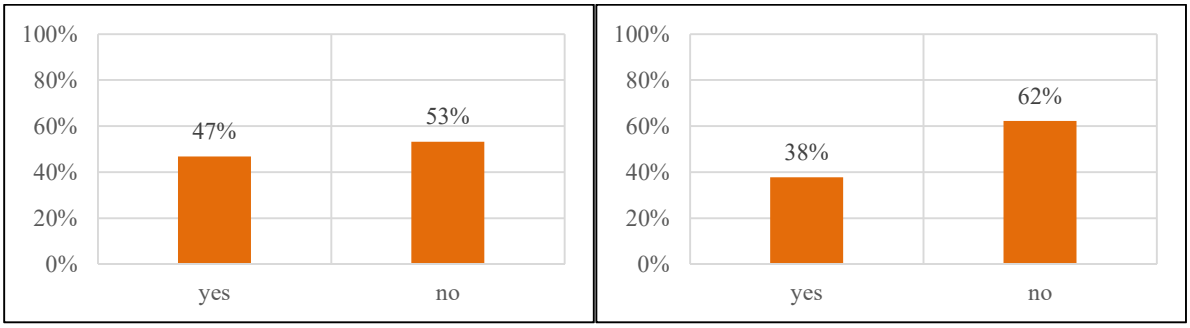

Figure 10. Distribution of responses to the question do they work fixed working hours (beginning, break, end) in public sector (left) and private sector (right).

As it can be seen in Figure 10, 53% of workers in public sector and 62% of workers in private sector did not have fixed working hours.

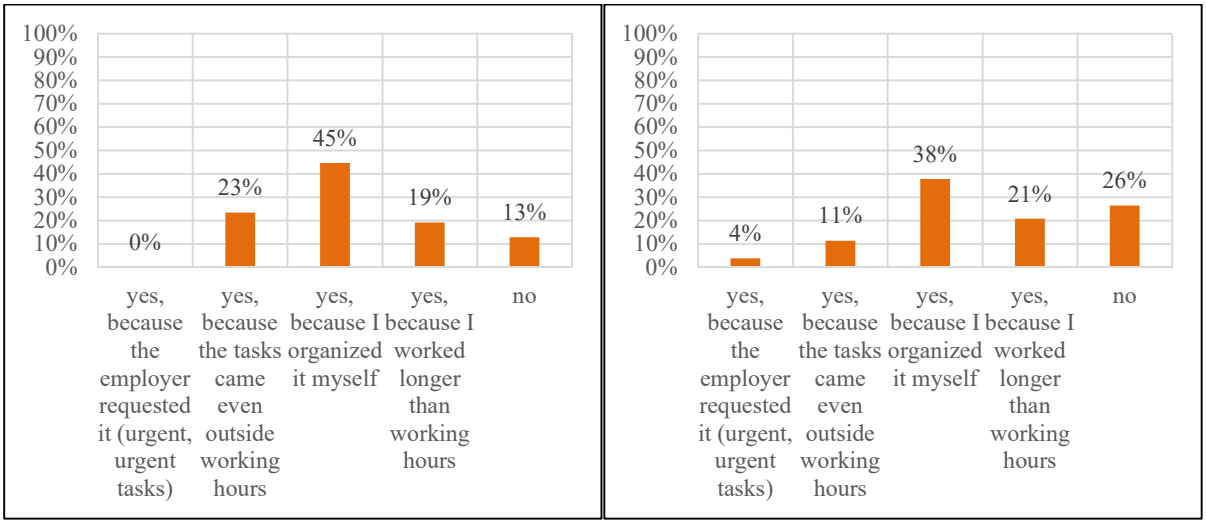

Figure 11. Distribution of responses to the question did they work outside the fixed specific working hours in public sector (left) and private sector (right).

When working hours were considered (Figure 11), the majority of employees in the public sector worked outside of working hours (87%), as did the majority of employees in the private sector (62%). An important fact is that most employers did this because they organized it in that manner themselves (flexibility as an advantage), i.e., 45% in the public sector and 38% in the private sector.

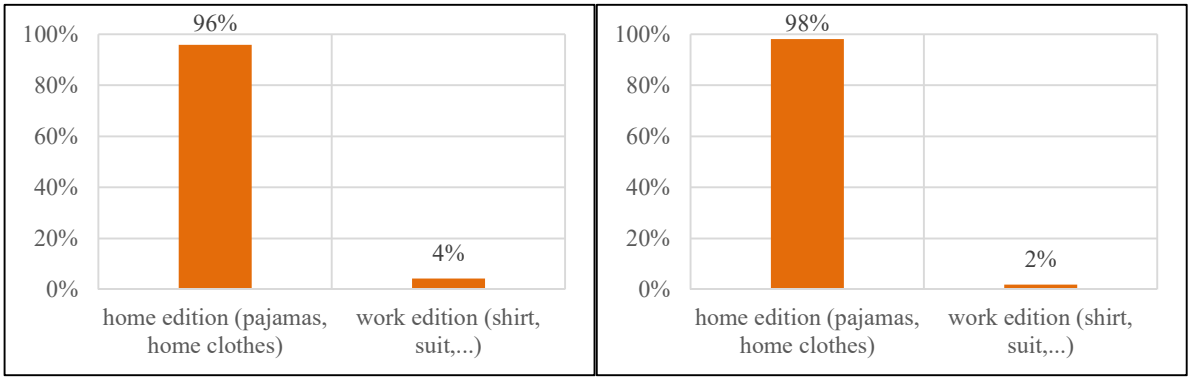

Figure 12. Distribution of responses to the question about the way they dressed while working from home in public sector (left) and private sector (right).

According to Figure 12, a great advantage is comfort and cost reduction in clothing (96% public, 98% private). Employees contact their co-workers when working from home (Figure 13).

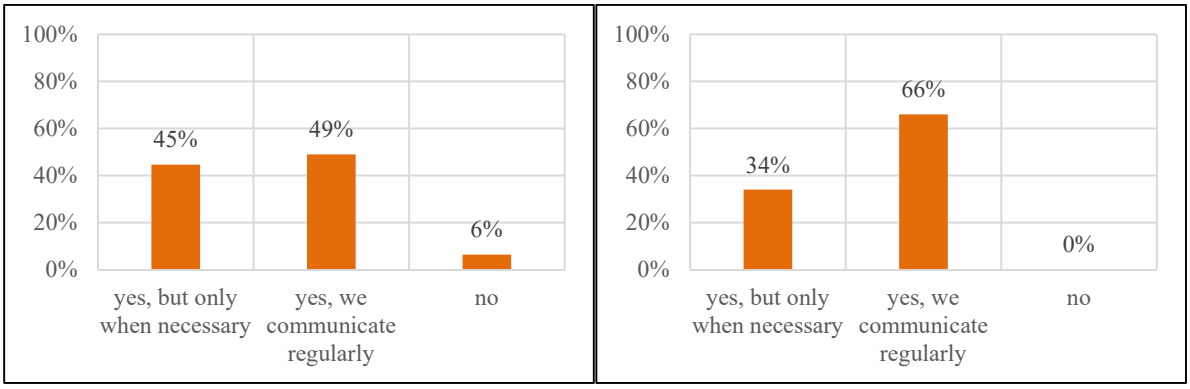

Figure 13. Distribution of responses to the question do they maintain contact with co-workers when working from home in public sector (left) and private sector (right).

To the question whether they feel safe while working from home, 51% of employees from public sector and also 66% of employees from private sector answered they feel safe. As some of the advantages of working from home, employees mentioned flexibility, less commuting, while they pointed out as disadvantages technical difficulties, over-time, burnout, which coincides with earlier research [7] and results shown in Table 2.

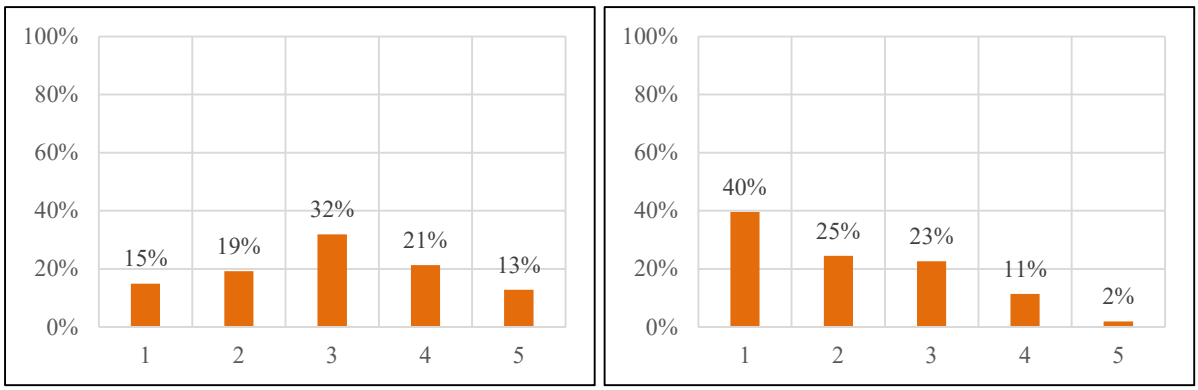

Figure 14. Distribution of responses to the question to assess to what extent do you consider working from home to be a stressful way of working (from 1 to 5) in public sector (left) and private sector (right).

As it can be seen in Figure 14, most of responders in public sector consider that working from home is moderately stressful (32%), while most of responders (40%) in private sector consider that working from home it is not stressful at all. Most of employees in private sector (47%) consider that working from home does not interfere their daily, weekly and annual vacation, while employees from public sector consider that working from home has an impact on their vacation (Figure 15).

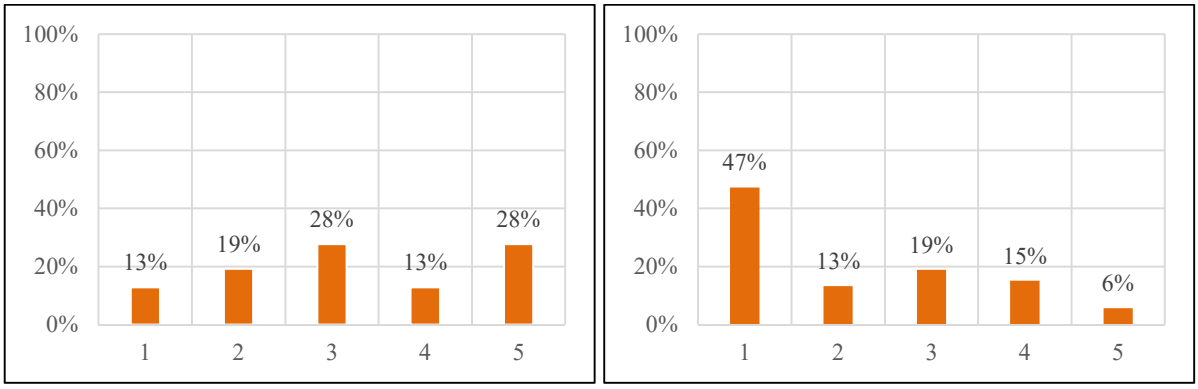

Figure 15. Distribution of responses to the question to assess to what extent does working from home interfere with daily, weekly and annual vacation (from 1 to 5) in public sector (left) and private sector (right).

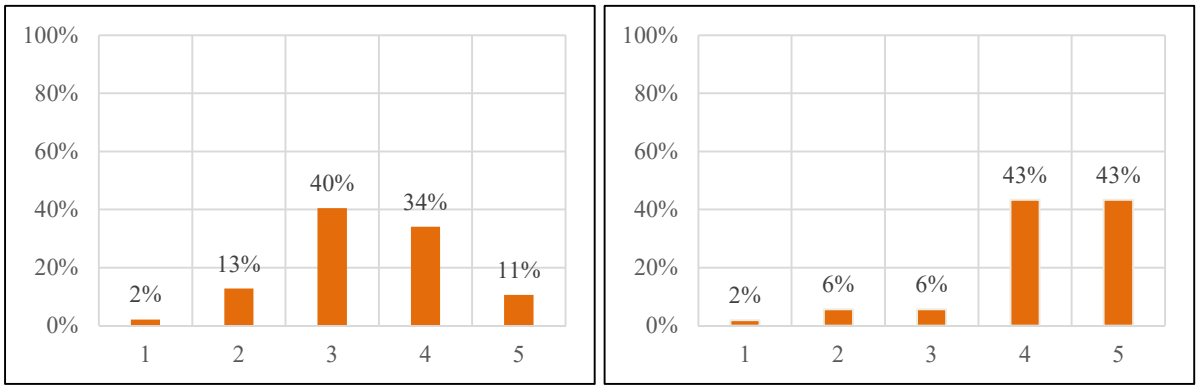

Figure 16. Distribution of responses to the question to assess to what extent they are effective while working from home (from 1 to 5) in public sector (left) and private sector (right).

Employees from private sector consider that they are more effective when working from home, while employees from public sector consider they are moderately effective (Figure 16). When impact of working from home on the life habits of responders and their household members is considered (Figure 17), employees from public sector consider that working from home has a greater impact on their habits, that employees from private sector. Also, according to Figure 18, 87% responders from private sector consider that they have the necessary conditions for work and concentration when working from home, while only 53% of responders from the private sector consider that they have satisfactory conditions.

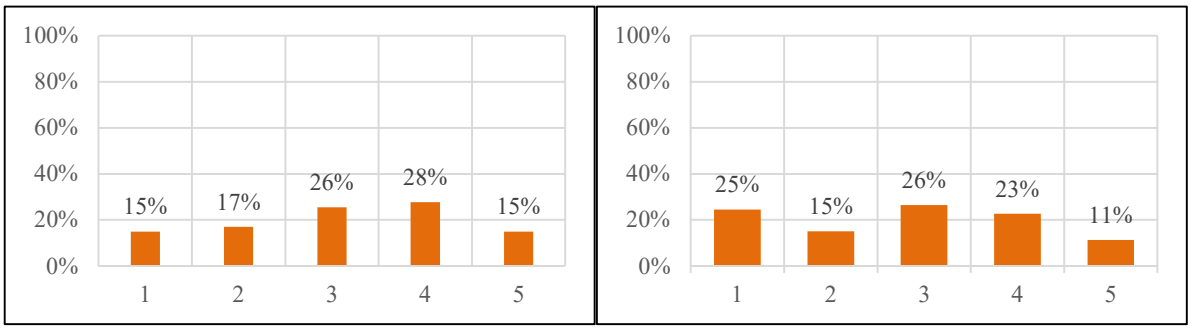

Figure 17. Distribution of responses to the question to assess to what extent working from home influenced the life habits of them and their householders (from 1 to 5) in public sector (left) and private sector (right).

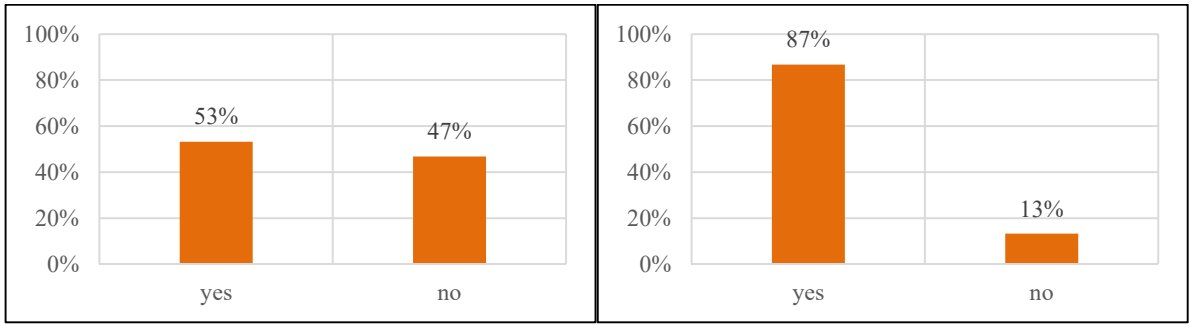

Figure 18. Distribution of responses to the question do the responders have the necessary conditions for work and concentration when working from home in public sector (left) and private sector (right).

Some of the most common answers to the question what employees would change about the working from home are shown in Table 3, and it can be seen that employees from public and private sector agree that there must be a balance between private and business life and also that employer must participate in the costs.

Table 3. The most common answers what employees would change about the working from home.

PUBLIC SECTOR	PRIVATE SECTOR
Space and equipment for work, special room for working	Separate room to work, better resolution of what is private and what is business
Work only 8 hours, frequent break	Fixed working hours, reduce working from home to a minimum, only when necessary
That employer pays a certain amount for household expenses	That the employer is obliged to provide equipment for work and to pay at least part of the costs of electricity, water, etc.of working from home, which will be tax recognized

6. Conslusion

We can conclude that the majority of employees worked in their homes without remodelling or additionally equipping the space, which means that for the majority of the employees, their place of work possessed part of their private space, i.e., home. Also, the employer did not provide for all the necessary equipment, which means that the employees used their private furniture and/or equipment for working. The employers saved costs for the premises and equipment. Additionally, to the costs of premises and equipment, the employer saved on costs for heating, internet, phone, and others.

But, the employees still perceive the benefits of working while the employees themselves have some savings from working from home, first of all expenses for dressing and transportation to work. We should keep in mind that some employers compensate these expenses to the employees, but also that employees find it very positive that they save time and effort usually spent on traveling to work.

When taking into consideration how working from home affects private and family life, it is important to analyse answers to questions about working hours. On one side, the flexibility of conducting work tasks outside of working hours can be an advantage if it is done at the will of the employee and contributes to work and life balance, but it can also pose a risk of workaholic and burnout situations where home transforms into a place of work.

Working from home should balance the interests of the employer and those of the employees, but with great care for the employees' wellbeing and work-life balance. The most important thing is that this kind of work is voluntary, agreed upon by both parties, that contractual provisions are clear, and that all obligations are defined in detail so that this kind of work fulfils both employers' and employees' expectations.

Employees should be safe and protected from all kinds of professional risks, including disruption of the balance between work and life and excessive working hours, i.e., workaholism.

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The primacy of the existential aspect in the potential reasons for entering into entrepreneurship

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Abstract. Reasons why people choose to start a business are different. Bosnia and Herzegovina which is still in development process needs to work on motivating and exploring ways for innovation and new businesses. This paper examines answers to the question which was posed to citizens in Bosnia and Herzegovina by using questionnaire as a research tool. The question with the key word "make" was: "What would make you to become an entrepreneur in Bosnia and Herzegovina?". For each category of the reasons, the percentages of responses in relation to the total answers that served us to rank the reasons that would make respondents to become entrepreneurs were calculated. Based on the analysis we can conclude that the existential aspect has primacy over other categories (profit, social aspect, idea, business conditions, independence), which means that in Bosnia and Herzegovina entrance intro entrepreneurship will continue out of necessity and not from opportunity. This finding can serve as a potential important implication for what needs to be changed and done in order to help our country to increase its competitiveness and economic growth with significant changes in stimulating entrepreneurship.

1. Introduction

In Bosnia and Herzegovina (B&H) most of the newly established businesses are based on copying businesses that already exist. There is a lack of innovation on the scene. Bosnia and Herzegovina is a developing country, while in developing countries, the benefits of innovation by entrepreneurs depend on the characteristics of the system of innovation within which they are embedded [1]. According to the Global Competitiveness Index (edition 2019) among 141 countries, Bosnia and Herzegovina is ranked 92nd for the overall score and when it comes to innovation capability B&H takes 117. place. Therefore, this is the field in which action must be taken since innovation and development represent the cause and effect of entrepreneurship [2]. Innovations are drivers of a new economy [3] and represent an unavoidable part of the entrepreneurial economy. Innovation and entrepreneurship generally go hand in hand [4]. New definition of entrepreneurship is about innovation; about seeing problems as opportunities, and about changing the world [5].

This paper presents part of the results from the research in which an attempt was made to identify the factors that influence entrepreneurial intentions in Bosnia and Herzegovina.

2. Entrepreneurship and innovation in Bosnia and Herzegovina

The role of the entrepreneurs is crucial in creating new economic activities that help to generate wealth, jobs and growth, as well as ensuring the well-being of society [6,7,8,9,10]. Entrepreneurs innovate. Innovation is the specific instrument of entrepreneurship [11]. During the pre-war period in Bosnia and Herzegovina there were large companies and institutes which had created innovations. Such system had almost disappeared (large enterprises breakup, privatization, breakup of institutes, the disconnection of higher education and the economy) and it is necessary to rebuild it as a link between the business sector, institutes, higher education institutions and governments. Great attention is paid to the importance of entrepreneurship for the economy of the country and in order to achieve competitive advantage encouraging innovative businesses is out of great importance. Without improving the cooperation between science and the economy, there is no economic development and therefore investments in innovation and increasing competitiveness are necessary [3].

Entrepreneurship in Bosnia and Herzegovina is not desirable because people prefer public sector and security that this sector brings in terms of income, long-term employment, reduced risk, etc. People's willingness to engage in entrepreneurship is on low level. The willingness and desire to enter into entrepreneurship is low although people consider themselves capable for entrepreneurial venture. However, certain changes in the fluctuation of the workforce from the public to the private sector are noticeable. Also, employees in the private sector in Bosnia and Herzegovina are more inclined to entrepreneurial behaviour compared to employees in the public sector [12].

But when it comes to Generation "Z", "the generation of future" also known as Gen Z, which is the new focus of many studies [13,14,15] things change. Characterized by their interest in technology, more than previous generations, especially in digital technology, is generation with emphasized entrepreneurial spirit which is ready to become entrepreneurs more than any other previous generation. With entrepreneurial spirit this generation is creative, flexible, risk taking, etc.

Unlike earlier research (from 7-8 years ago) on a sample of students in those generations who did not consider entrepreneurship desirable but felt relatively capable of entrepreneurial ventures; "today's high school and college students" or Generation Z consider entrepreneurship more desirable, but at the same time do not feel capable of entrepreneurial ventures. As a result, we can conclude that there is an increase in the degree of desirability of entrepreneurship, a decrease in entrepreneurial self-efficacy and latent changes in entrepreneurial intentions. That is, entrepreneurial intentions remain at a lower level in Bosnia and Herzegovina [15].

The importance of innovations also arises in the 2030 Agenda for Sustainable Development because innovations are one of the 17 sustainable development goals (SDG) of this Agenda and in order to ensure long-term business success innovation is necessity. According to the Federal Institute for Development Programming and Report on the Competitiveness of Bosnia and Herzegovina 2020 [16], when it comes to innovation ecosystems in B&H a paradox had emerged recently because in the last decade there is positive development of entrepreneurial culture but on the other hand a number of new companies and technology breakthrough has decreased. A greater intention should be paid to the factors that had contributed to this decline in order to get a broader picture. Therefore, fostering and supporting innovation is a key for economic growth, productivity and new jobs.

According to the Labor Force Survey 2019 [17], in Bosnia and Herzegovina the total number of self-employed people was 21.9 % with more male than female self-employed persons. According to the data of the Women's Entrepreneurship Report 2018/2019 by GEM [18], TEA rate for our country is the lowest compared to the regional level. When it comes to necessity as a motive, in Bosnia and Herzegovina (% of TEA women) is 46.4% while for man it is 19.2% (% of TEA man). This data shows that for our country for women necessity is a motive for starting a business rather than it is for man. However, the general level of perception about entrepreneurial opportunities is low among both men (15.8%) and women (11%) in Bosnia and Herzegovina [19].

When it comes to competitiveness and inclusive growth for Bosnia and Herzegovina, according to the European Commission Bosnia and Herzegovina made limited or no progress in most areas of competitiveness and inclusive growth (taxation, digital transformation and media, social policy and

employment, enterprise and industrial policy, science and research, education and culture) and some progress in the area of customs union. The country showed backsliding in other areas (economic and monetary policy) where it is at an early stage or has some level of preparation. These areas have significant links to the country's Economic Reform Program. Bosnia and Herzegovina needs to introduce socio-economic reforms to address structural weaknesses (including low competitiveness and high unemployment), and the impact of the COVID-19 pandemic [19].

3. Research methodology

In this paper answer to the question "What would make you to become an entrepreneur in Bosnia and Herzegovina?" has been analysed. Respondent were asked to answer the give a question in written form. This paper analysis answers on the sample of 84 respondents (N=84). The questionnaire was distributed online by using Google forms.

In given question we had used the verb "make" in a targeted manner since we wanted to avoid the answers that appeared in earlier research that had related to lack of interest in entrepreneurship. As stated previously, based on the context of textual answers to the question posed, the answers were summed and categorized into six different categories (profit, existence, social aspect, idea, business conditions, independence).

Then for each category we have calculated the percentages of responses in relation to the total answers that served us to rank the reasons that would make respondents to become entrepreneurs. "In qualitative research, the results are mainly divided into topics and subtopics, while claims are supported by citations of participants in the research".

4. Results and discussion

Based on the research methodology, through the analysis of a given answers, six groups of answers were created and presented in the Table 1.

Table 1 Rank of grouped responses.

	Groups	**Frequency**	**%**	**Rank**
2.	*Existance*	27	36	I
5.	*Business conditions*	19	25,33	II
6.	*Independence*	11	14,67	III
3.	*Social aspect*	9	12	IV
4.	*Idea*	5	6,67	V
1.	*Profit*	4	5,33	VI
	TOTAL	75	100	

According to the statements of 84 respondents who had delivered their answers in written form six of them (7%) had stated that there is no chance or motive or reason that would „make" them to become entrepreneurs in Bosnia and Herzegovina. The answers from three respondents couldn't be interpreted as a reasons. As it can be seen in Table 1 the highest ranked grouped answer is existance (which refers to unemployment, existance, etc.) and profit is at last 6th place.

Examples of answers that respondents had stated and because of which we had decided to perform this categorization are shown in the Table 2.

Table 2. Examples of answers which are used to categorize the reasons.

Group	*Usual answers.*
Profit	Profit, earnings
Existance	Own existence

	Desire to secure a better future for my child Unemployment Termination from current job Inability to find another job Inability to find employment and existence in middle age If I didn't have a job for more than a year Loss of current job Loss of hope for advancement in current job Better existence for the family
Social aspect	Desire to employ young people which there is less and less Desire for change, something new, creating value I would like to help young people in acquiring work habits, employment of youth Current economic situation in order to keep young people in B&H Improvement of the economy of B&H Securing jobs for others Well-being of the local community In 2010 I became an entrepreneur because I believed I could contribute to the development of B&H The previous attitude of entrepreneurs (private individuals) towards workers, which I would try to change
Idea	Good idea Having my own business leaves more freedom and more opportunities to realize my ideas Desire to present my ideas to the market and desire for success
Business conditions	Better conditions for establishing a company Better relationship between BH authorities and structures towards entrepreneurs Financial assistance and better legal regulations Economic situation Economic opportunity, the possibility of standing out in the field of entrepreneurship; better relationship between government and authorities towards entrepreneurs Simpler procurement of public administration and public assistance for managing a company More education and information that is hidden from the public. Knowledge and research that should be available to everyone is privatized. Loan with a lower interest rate
Independence	To become independent. To work for myself and to be independent

So for example one of the answers was: Nothing would made me because the state is in collapse and it doesn't care for citizens, it doesn't give any support. Although this answer has an elements of business conditions and as we have already stated, we have targeted the term "make" to find out under what motives, reasons and conditions citizens in Bosnia and Herzegovina would enter into entrepreneurship, quite expectedly there is a part of citizens for whom there are no reasons under which they would become entrepreneurs.

5. Limitations and future directions

Despite the fact that this paper has several limitations it must be noted that this paper still contributes to the study of entrepreneurship in Bosnia and Herzegovina. One of the limitations refers to the number of respondents (N=75). Also, limitation of the current study is using the question "What would make you to become an entrepreneur in Bosnia and Herzegovina?", because there is a chance that this question associated respondents to "necessity". The recommendation for future research is to use and the question What would motivate you to become an entrepreneur? Next research can include larger number of

respondents in order to test the validity of the results. Also, when it comes to statistical data that is needed for the reliability and credibility of the research in Bosnia and Herzegovina there is a lack of up-to-date data.

6. Conclusion

It can be seen that Bosnia and Herzegovina is faced with many challenges and unemployment is one of them. With the COVID-19 pandemic the number of unemployed persons had increased and B&H needs to promote entrepreneurship and innovations as one of the potential responses to high unemployment. There are different reasons to start being entrepreneurship as it can be seen from the formed group of answers in the result and discussion part. Mostly people start a new business because of necessity motive or because of an opportunity as a motive for entrepreneurship. Based on the respondents' answers it can be seen that in our country, according to the respondents in the research, existential aspect has primacy over other categories (profit, social aspect, idea, business conditions, independence). According to the respondents because they were unable to find job or because they are faced with job loss or because they want to secure their existence and better future of their child respondents may choose to start their own business in order to secure themselves and their families.

Also, Bosnia and Herzegovina needs to adjust and to adopt policies to strength entrepreneurship and innovations. Different stakeholders should be involved in order to work on areas for improvement in entrepreneurship and innovation ecosystems. Building positive attitudes that will encourage entrepreneurship and entrepreneurial way of thinking should be encouraged. When it comes to innovations, despite the positive development of entrepreneurial culture, B&H has the lowest rates compared to the countries in the region.

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Selected Opinions on Muslim Resolutions of 1941 – Continuity of Statehood

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Abstract. In recent years, the Muslim resolutions of 1941 have increasingly attracted the attention of both academia and the social public. From the exclusively affirmative opinions in the older literature, today exists a different way of approach and interpretations of resolutions, so that final judgments about the purpose and goal of these resolutions have new dimensions. As a small contribution to the eighty-year existence of resolutions, the author in this paper presents and analyzes selected opinions on the essence and significance of resolutions.

1. Introduction

An intellectual does not arise from an academic title, social position, number of books both read or written, nor from other formal (read: formalistic) elements, which certainly influence the creation of the general public's opinion about that person. On the contrary, an intellectual is defined by his actions, or, in the case when action is impossible, by courage to publicly state and articulate one's opinion, even at the cost of personal harm in any sense. We should not forget the context of time and space in which that intellectual thinks, reflects, criticizes and acts with the aim of realizing his own ideals and values, which are socially useful, moral, ethical and timeless. In this sense, intellectuals can live in a healthy socio-political system where freedom of thought and expression is a guaranteed constitutional right, and yet, they can also live in a time where dictatorship and general social unrest do not even guarantee the right to life, let alone opinion. While some operate in peace, others experience the circumstances of war. And so indefinitely...

As an expression of dissatisfaction with the crime of so-called The Independent States of Croatia (hereinafter: NDH) - puppet under the direct authority of Berlin, the academic and social Muslim elite decided in the fall of 1941 to publicly oppose the crimes committed by the Ustashes and 'Ustashes with red fez', calling for the prevention and cessation of crimes, peace, tolerance and respect for others and others. In a period of unprecedented suffering, when the whole of Europe was trampled under the boot of Nazism and Fascism, while in Bosnia neighbor tortured neighbor - or brother brother, many promiscuously sided with the biggest criminals in the history of mankind, while others (wisely) remained silent, fearing for their own existence. In that period, it might have been masochistic to speak out loud, let alone stand up publicly against Ustasha-Nazi crimes and, according to some - against the regime.

The six resolutions, which were passed and made public by Muslims, represent the first known case of public protest in the whole of Europe, which in recent decades has intrigued not only domestic but also foreign historians, lawyers, sociologists, political scientists, theologians and others. Given that it has already been eighty years since the adoption of the resolutions, the author, with the intention of

making his small contribution to the study of this topic, decided to separate and analyze selected comments and opinions about the nature and goals of the Muslim resolutions, which are certainly gaining importance in these gloomy times.

2. Historical background of studies on resolutions

Six synchronized resolutions that were created in 1941 in Sarajevo, Banja Luka, Tuzla, Bijeljina, Mostar and Prijedor[1] by Muslim intellectuals (ulama), prominent figures of social, political and cultural life, representatives of various institutions and associations, were created during one of the greatest crises in the history of mankind. Starting from the month of August, the entire hierarchy of the Islamic community, from hojas, imams, kadis, teachers and professors, headed by the reisul-ulema, signed the text of these resolutions. The original creators of the Sarajevo Resolution were probably Mehmed Handžić and Kasim Dobrača, who was sentenced to prison by the communist authorities in 1947 as a 'traitor of people'. The resolutions were passed in the period of half a year (and later) after the establishment of the NDH, which certainly should not be ignored, given that the leaders and officials of this Nazi creation, conditionally speaking, were given the chance and opportunity to establish their rule on the civilized foundations - that was certainly not the goal of its original creators. The result of resolutions is that "the Muslim champions and ilmiya influenced the masses not to join the Ustasha and to deny them help, which they mostly succeeded" [1].[2] Nevertheless, both because of the fact that some Muslims joined the Ustasha and because of "Ustasha with fez on their heads"[3], but also the old, well-known chauvinism that ruled in certain centers of power, conditioned that the Chetniks committed other crimes against Muslims, which will certainly not be the subject of a detailed study in this paper.

With the goal of an objective and academically correct approach to historical events, it is clear that "generalizations are misleading, as well as connecting the deformed past with the present" [2]. A one-dimensional and unambiguous approach has never given birth to the truth, so it is very important to approach every event objectively, impartially and from different dimensions. The study of the text and goals of the resolutions has been actualized in the last decades, even though this topic was dealt with by distinguished authors in the 'former states'. Thus, the first important intellectuals who actualized this issue were Avdo Humo and Adil Zulfikarpašić, Muslims who themselves were participants in partisan actions. After them, Muhamed Hadžijahić also dealt with resolutions, as well as other individuals from the former state. It goes without saying that it was difficult to express independent views on resolutions during communism. Some of intellectuals worked and wrote in 'exile', more specifically in other European countries. The approach and way of interpreting resolutions, that is, the opinions of authoritative experts, until the last twenty years, were exclusively affirmative. Today, this topic is studied by various experts with even more diverse professional references, so that the study approach has gained new dimensions in such a way that the resolutions are also subject to certain critical analyses. BiH's authors who have been studying this topic in relatively recent times are: Mustafa Imamović, Muhamed Filipović, Husnija Kamberović, Adnan Jahić, Safet Bandžović, Zlatko Hasanbegović, Hilmo Neimarlija, Denis Bećirović, Samir Beglerović, Fikret and Hikmet Karčić, Enes Karić and others. Also, it should be said that no doctoral dissertation on this topic is known to date.

3. Selected parts from the texts of the resolutions

In this part of the paper, the author singles out and connects the most interesting parts of the resolutions [3,4]. Even though they themselves were a victims, that is, even though they themselves were existentially threatened, the Muslims in the resolutions primarily call against crimes against Serbs and

[1] In the literature, it is often mentioned that resolutions were also passed in other cities, but those texts of the resolutions did not 'survive' the regime in the years after the Second World War. In this paper, the author will not dwell specifically on these resolutions, but it is desirable to mention the resolution of the Muslims of Zenica on the protection of the Roma, which was adopted the following year, ie in 1942.

[2] Of course, there were also Muslims who acted in accordance with the goals of the NDH, that is, those who were an integral part of this parastatal creation. Their positions were not so much responsible as the same were compromising. Also, they had an insignificant role in the military composition.

[3] It refers to the catholics (Croats) who abused the fez with the aim of creating intolerance between Serbs and Muslims.

Jews, stating in the Mostar resolution "countless crimes, lawlessness and violent turmoil that have been committed and which are made towards Orthodox Serbs and other fellow citizens". In addition to the general mention of the crimes committed, the Muslim champions in the Banja Luka resolution identify the victims and the way the crimes were carried out, mentioning "the killing of priests and other champions without trial and verdict, shooting and maiming in crowds, often completely innocent people, women and even children, persecution in the masses from home and from the beds of entire families." Furthermore, this led to the fact that "a choice was made with the property of evicted and refugee Serbs and Jews for robbery committed and wealth achieved for individuals, their families and friends", which openly, clearly and loudly mentions other material criminal intentions of the executor.

What is interesting and certainly supports the fact that resolutions are not only an act of symbolic resistance and represents a dissociation from the NDH is the fact that the Muslims, who prepared and signed the texts of the resolutions, refer to their homeland as Bosnia and Herzegovina (same in the Sarajevo resolution). The resolutions perceive this particular Nazi satellite state as the main and only culprit, which carries out all activities in a deliberate and organized manner, and at the same time, as stated in the Sarajevo resolution, creating "the belief that this is a system that is carried out deliberately". The parts of the resolutions mentioned above are the subject of numerous analyzes and interpretations, primarily because of their real ideological background, pure and clear positions that did not remain only in the sphere of symbolic reference to coexistence, law and justice, but also because real criminals and crimes were identified with them, as well as the responsible criminal organization (NDH).

Calling criminals to responsibility is certainly one of the most important elements of the resolutions, because it was really necessary to find courage and to 'invoke' criminal responsibility of those who played key roles in the political and other structures of this parastatal creation. Thus, the Sarajevo resolution demands that "all real culprits who have committed any violence or atrocity, as well as those who ordered or enabled such atrocities, regardless of their religion - to be brought to justice, and that the most severe punishments to be imposed". Here, as in the paragraph above, a clear distancing from the members of the Muslim nation who committed crimes is noticeable, given that they are also identified as 'real culprits' if they committed crimes.[4] So, in the context of holding members of one's own people to account, it can be easily concluded that the creators of the Muslim Resolutions did not have double standards when addressing the Ustashas and other fascists, which in any case represents one of the basic reasons why resolutions are being studied by the foreing historians, lawyers and others. Also, the criminal law aspect of the quoted text is indicative, given that, in addition to the perpetrator, initiators and principals are also held to account. Elements of command responsibility, which in the post-war period suddenly 'came to life' through the law and practice of numerous UN member states, are certainly recognized here.

Finally, the resolutions state that the Ustasha regime led a pagan and perfidious struggle with the aim of quarreling between Muslims and Serbs, as well as that Muslims are threatened with the same fate as the Serbs. Thus, in addition to the previously mentioned systemic abuse, the Mostar resolution requires a prohibition "when carrying out various actions, non-Muslims to wear fez... calling Muslim names and the like". The following is also stated in the Sarajevo resolution: "we note that, in order to shift responsibility for wrongdoing to Muslims, fez and Muslim names are used." The statement of the Muslims in the Banja Luka resolution is also interesting in this context. Without detailed analysis, we should definitely refer to the work of BiH historian Adnan Jahić, who often problematizes this issue in his paper.

4. Others about resolutions

As already mentioned, resolution are the subject of interest of many historians, lawyers, sociologists, theologians and political scientists, both on the domestic and international scene. In different periods, the resolutions were perceived and interpreted differently. Sometimes they are mentioned as a gesture

[4] In addition to distancing themselves from the domestic quinslings, the signatories of the text in the same resolution call on them to "strictly stay away from these crimes in the spirit of the high instructions of their religion ", clearly indicating that Islam is not a religion that allows committing crimes against anyone.

of humanism and multiculturalism, sometimes as a clear and loud anti-fascist message and even as a message to Hitler himself. The third, again, interpret the resolutions primarily as a way of protecting Muslim life (and then everyone else's). Although the resolutions did not achieve the desired goal[5], after all, they are "the voice of freedom in enslaved Europe, a voice that tried to draw attention to what is happening in Bosnia and that tried above all to protect members of other religions, their property and cultural heritage, but also Muslims who felt threatened in the new state – NDH" [6]. Anyway, time will be the best indicator in which direction the interpretations will go. In this part of the paper, the author presents selected comments and opinions of domestic and international experts.

If the focus is temporal context, it should be concluded that resolutions were passed in the most difficult period, that is, in the period of the peak of crimes against Serbs, Jews, Roma and others. They represent "an expression of civil courage and coexistence in Bosnia and Herzegovina" [6], as it's noted by the adviser for culture and religion of the Jewish community in Bosnia and Herzegovina, adopted in a period when human life was worthless. The resolutions stemmed from the "Muslim autonomist opposition to the Ustasha" [7], and "rejected the policies and values of the NDH", which consequently caused "Muslim opinion to firmly turn against the Ustasha regime"[8]. As a gesture of civil morality and courage, they clearly show that one cannot respect the legal order that bases its existence on the crimes against oppressed and weaker, or simply because they belong to a different ethnic or religious group. In addition to confirming the historically undisputed fact that the Muslims want to distance themselves from the NDH and Ustashi crimes within the same organization, some authors believe that the resolutions were addressed to the German authorities [9]. Adil Zulfikarpašić states that the resolutions "are the authentic attitude of Muslims towards NDH, and that we (Muslims – added by author) also had our collaborators, we do not hide that" [3]. He concludes that the Muslims had their legitimate representatives behind the resolutions, stating that "these are the representatives of the people, this is the people and this is what our people thought and that's how they judged the country" [3]. Therefore, the majority of Muslims ideologically accepted the ideas of the resolutions, that is, they were ideologically opposed to the ruling fascist system. If one were to draw a historical parallel between the ideological frameworks of the majority of Muslims at the time and the current state of consciousness of the Bosniak people, it would be possible to conclude that the moral ideals remained almost identical, that is, unchanged.

If we make a distinction between violent and non-violent resistance to the fascist system, it is certain that we can classify the resolutions in the second-mentioned category. Hikmet Karčić claims that "the phenomenon of Muslim resolutions, with the appropriate historical context, can be considered one of the best examples of nonviolent resistance in the territories of occupied Europe" [11]. He further claims that resolutions were "distinguished by a more organized, quasi-institutional character with the aim not only of condemning crimes and distancing from the same, but also of pointing out the suffering of their own people" [11]. Precisely on the basis of resolutions that were resistance to the crimes committed by the Ustashas, the National Liberation Movement presented the basis for the inclusion of Muslims as an equal and inevitable factor on the battlefields since 1942. This "laided the foundation for equal treatment of Bosnia and Herzegovina in the new federalist conception of the anti-fascist movement" [12]. The question of the Muslims' national affirmation in the post-war period was certainly linked to the resolutions that were created in the war period, but also through the partisan movement that not only "restored the subjectivity of the Bosniaks, but also resolved the issue of the statehood of Bosnia and Herzegovina"[13].

Certainly, the consequences of creating the resolutions were not absent. Noel Malcolm notices that the creation of these resolutions is a consequence of the dysfunctionality of the rule of law and the disappointment of the Muslims in the government, concluding that "the promise that all their rights would be respected was not kept" [15]. After that, he states that the resolutions conditioned the deterioration of relations between Muslims and the state government, which Berlin was also aware of,

[5] The author of this paper is referring to the multiplied and unprecedented crimes that followed in the years after the resolutions were created.

that is, what the Germans reported on. In the time after the resolutions were created, the Ustashas and domestic Quislings further worsened relations with the Muslim leaders, but also with the ordinary people – those that did not accept the 'swastika' ideology, who were then punished in different ways. In terms of the direct consequences for the Muslims who led the idea of the resolutions, academician Muhamed Filipović, who was also born in Banja Luka, pointed out in his interviews that the leading people who prepared and signed the Banja Luka resolution ultimately ended up in the Stara Gradiška camp.

On the other hand, there are authors who interpret resolutions through the prism of historical revisionism of pro-Bosniaks oriented historians, and not as an act that was really directed against the government and behind the ideological background of the Muslims' majority in Bosnia and Herzegovina. Thus, Mirjana Kasapović states that "the Muslim resolutions were neither anti-Ustashi nor anti-fascist acts, but rather protest letters with limited political goals: to influence the state in order to prevent and monitor religious and ethnic violence and to protect the Muslim population from violence, as well as to release them from responsibility for violence against other communities" [16]. The reading and interpretation of such views should be approached cautiously and the answers to such conclusions should certainly be given by more experienced historians and lawyers, taking into account the following elements: the nationality of the author, the country he/she comes from, his/her academic reputation and the political background of the text. It is clear that the authors who see BiH as a historically Croatian or Serbian country are politically and nationally 'colored', wanting to attribute the crimes of their own people to other nations at any cost. Calling a sovereign and independent country as 'your own', without reference to the fact of its thousand-year existence and tradition (which the country that issued the author's passport should clearly be envious of), probably represents the clear definition of historical revisionism. In contrast to these ideologically controversial texts, there are also authors who base the criticism's dimension on much more objective and factually acceptable grounds. Thus, Robert J. Donia recalls the historians who acted and worked in the former Yugoslavia – historians who emphasized that "the signatories of the resolutions criticized the crimes as deviant excesses, but did not attack the key Ustashi program of violent physical elimination of certain groups. He added that they, however, did call on the NDH authorities to restore order and prevent further violence" [17]. Others, like Tomislav Dulić, 'regret' that Muslims opposed (only) to murders and not discrimination in the context of property and confiscated administrative positions of Serbs. However, there is no text of any constitution, law, by-law or any other form of collective or individual will expression that is absolutely perfect and cannot be subjected to criticism - starting from the US Constitution to the press releases of some administrative state bodies. It is the same with the Muslim resolutions from 1941. Perhaps, for the sake of a correct understanding of historical truth, this is precisely the way to understand their purpose and significance as clearly as possible.

In the end, it is certain that these resolutions will remain the subject of study and analysis, given that a certain time distance is needed in order to adequately and objectively look at certain events from the past. In this sense, assuming various activities of intelligence services from many centers of power in the period when the resolutions were prepared, signed and further distributed, Enes Karić calls for archival research on the possible 'documentation process' of these resolutions in certain Western countries (Germany, Austria, France and England), but also in countries that are oppositely geographically positioned (primarily Serbia and Turkey). In addition, the same author calls for more detailed research in the institutions of local religious communities, primarily the Islamic community, but also within the institutions of the Catholic and Orthodox churches.

5. Concluding remarks

Ignoring the formal and formalistic elements that influence the public opinion about specific person, the concept of an intellectual given in the introduction of this paper certainly refers to the group of Muslims who found the strength and courage to publicly express and articulate their own opinion in 1941, considering that during wartime circumstances and within cruel regime, there was not much space for real action (and how else can intellectuals act, but with voice and feather?!). As great works outlive their creators - Muslim resolutions outlived their authors. Beside that and through increasingly intense

academic discussions, relatively speaking, the resolutions seem to be 'reliving their youth'. Considering all the above-explained, these academic discussions should be approached with extreme caution, considering the various background ideologies whose agitators are those who experience and interpret historical events in a single sense, "connecting the deformed past with the present" - as explained by Bandžović. While using historical revisionism as a basic tool in they work, those should not even be called intellectuals.

However, it is easy to criticize everything - while doing nothing! Diplomatic scandals experienced by the representatives of major Western countries (just think of the 1936 Olympic Games or the splitting of sovereign Czechoslovakia), the defeatist role of the indolent and overbearingly impotent League of Nations, the tacit approval of crimes against Jews throughout the Third Reich (all this before the war even started), certainly not favor those who blindly and unreservedly believe in so-called western civilizational values. Usually, such people criticize everything except what they perceive as their own, contemplating along the way when faced with real problems. And those were certainly not the Muslim intellectuals in 1941, whose voice was heard far and wide!

In the end, it is certain that these resolutions will remain the subject of study and analysis, given that a certain time distance is needed in order to adequately and objectively look at certain events from the past. In this sense, assuming various activities of intelligence services from many centers of power in the period when the resolutions were prepared, signed and further distributed, Enes Karić calls for archival research on the possible 'documentation process' of these resolutions in certain Western countries (Germany, Austria, France and England), but also in countries that are oppositely geographically positioned (primarily Serbia and Turkey). In addition, the same author calls for more detailed research in the institutions of local religious communities, primarily the Islamic community, but also within the institutions of the Catholic and Orthodox churches.

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The Importance of Digital Marketing in Creating an Interactive Relationship of Supply and Demand in the Market

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Abstract. The rapid spread of information, the widespread presence of the Internet, social networks, the increasing general awareness of the importance of information literacy in modern living and working conditions, directly affect marketing communication. In modern market conditions, traditional marketing techniques are no longer popular with the customer: today's customers are more informed, they cannot be deceived, they know what they want and how to spend their money, where they can commit to a purchase with a valuable word of mouth. ke about shopping. Customers today want and demand the right information - the information that will make the most sense for them, that will solve their problem. For these reasons, today the focus is on a new marketing reality based on helping customers solve their problems. Digital marketing is the most popular way of advertising products and services. This model of Internet advertising is not based on promotion, persuasion and messaging, but aims to deliver content at the time and place where it is requested. Success requires focusing on customers and addressing their needs.

1. Introduction

Digital marketing or so-called e-marketing implies a set of marketing processes that use all available digital channels to promote products or services how a certain message would reach the primary audience, mainly for brand building. They are today we have at our disposal thousands of different online channels through which anything can be done order to service users. New services, after trying them out on stage, popularity first grows, only to gradually fade immediately afterwards - interest is born slowly, it develops over time and then slowly disappears and this is a normal course. Today it is the majority companies switched to advertising through various forms of digital marketing, and less and less companies use newspaper ads - precisely because people use the Internet more and more today and that the information age is the fastest growing phenomenon known to society. In modern economic theory and practice, the concept of the triangle "market-marketing-trade" is very important and present. First of all, the importance of the connection between these three categories, and then the key roles they play in marketing channels [5].

Digital marketing represents the use of information technology in the process of creation, communication and delivery of value to clients, is the result of informative technologies applied to traditional marketing. The average global marketer invests an average of 20% to 35% of their budget

in digital marketing, depending on the category products or services it sells. When we talk about the Internet and in general about the e-commerce that we mentioned above, we can and define: it implies the sale of goods / services through electronic channels communication, primarily the Internet, and the name is short for electronic commerce. Created is as a result of the need to efficiently satisfy the needs of modern consumers which require salespeople to be available 24/7 a week, worldwide. Today, almost all products / services can be sold electronically; from books to music, clothes and shoes, air and other transportation. The largest and most famous electronic retailers in the world are Amazon and eBay [3].

2. Digital marketing

Marketing has always been about connecting with your audience in the right place at the right time. In the present, that means reaching them where they spend most of their time: on the Internet. Digital marketing encompasses all marketing efforts that use an electronic device or the Internet. Companies are leveraging digital channels like search engines, social media, email and their websites to connect with current or potential customers. It reduces the cost of communication service because the internet is much cheaper and, in some cases, even free. E-marketing offers more flexibility, which allows the marketer to constantly adjust its offer and programs. The advantages of advertising on the web are low costs and the possibility of creating ads that will contain both sound and images, and the possibility of finding another page with additional, complex content. From the marketing side of social networks, many audiences use them to discover, search and educate themselves about a brand.

Therefore, it is important to engage in that area as well. This practice promotes branding and content to social media channels to increase brand awareness, drive traffic and generate business leads. Channels used in social media include Facebook, Twitter, LinkedIn, Instagram, Snapchat, Pinterest, Google+, YouTube, and more. The advantages of social network marketing are relatively low campaign costs, quick feedback, increased traffic to the website, strengthening of the brand, simple and quick launch of new products or services. Using digital marketing, it is possible to measure the influence of all channels, e.g. the number of visitors to the page, the time spent on the page, what exactly is viewed, and based on that calculate profitability and what else can be changed to improve it. For the firm, the most important thing is reduced costs, because the effectiveness of each channel can be measured, and you can focus only on profitable channels and ignore the others. An easier increase in income can be achieved by collecting the data that the user has searched for on the web shop, and in this way discounts are sent to him via e-mail.

On the Internet, it is important to be found on a search engine. Increasing search engine visibility is not possible without quality content. Creating fresh and quality content should be edited in the form of image ads that offer discounts on furniture purchases, discount coupons, image galleries, videos and blogs. By editing quality content, the target groups are again influenced.

Retargeting allows marketers to show ads to customers who have been on a website while others are online. These ads often show specific products that a customer has viewed. It's a great way to drive conversions and make up for potential lost sales.

3. Demand as a market expression of consumption

The basis of all modern marketing is human needs - consumer needs. They form the essence of the marketing concept. The key to the survival, profitability and development of the company, despite the highly competitive marketing environment, lies in its ability to identify and satisfy unfulfilled consumer needs, and all this in a shorter time and in a better way than competing companies.

Providers do not create needs, although in some cases they can lead consumers to be interested in those needs that they did not feel before. Successful bidders define their markets in relation to the needs they plan to meet, not in relation to the products they sell. This approach to marketing is, therefore, focused on the market and not on the product.

Marketing orientation concentrates on consumer needs; production orientation concentrates on the needs of the seller. The marketing concept suggests that the producer will only produce what he knows people will buy, while the production orientation implies that the producer will try to sell what he initially decides to produce [6].

4. Motivation and consumer perception

Motivation can be described as a driving force in individuals that encourages them to act. This driving force arises from a state of tension that exists as a result of unfulfilled needs. Individuals consciously and subconsciously strive to reduce this tension, and they do so through behaviour that they sense will fulfil their needs and thus relieve them of the pressure they feel. The specific goals that individuals choose and the patterns of action they undertake to achieve the goals of results are individual thinking and learning. Everyone has a self-image (or multiple self-images) as a certain type of person with certain characteristics, habits, possessions, relationships and ways of behaving. Consumers often try to preserve, improve, change, or expand their self-image by buying products or services from stores that they believe match the image(s) they have of themselves, and avoid products and stores that do not. With the increased use of the Internet, "virtual selves" or "virtual personalities" appear. Consumers' experiences with chat rooms sometimes open up opportunities to explore new and alternative identities.

Perception is the process by which individuals select, organize and interpret stimuli into a meaningful and coherent picture of the world. Perception has strategic implications for providers since consumers make decisions based on their own perceptions, not on objective reality. The lowest level at which an individual perceives a certain stimulus is the absolute level of that person. The minimal difference that an individual perceives between two stimuli is called the differential threshold or barely perceptible difference. Consumers perceive most stimuli above the level of consciousness; however, weak stimuli can also be perceived below the level of consciousness (subconsciously). Witte et al. [7] refute the claim that subconscious stimuli influence the consumer's purchase decision. The selection of stimuli from the environment is based on the interaction of the consumer's expectations and motives with the stimulus itself. The principle of selective perception includes the following concepts: selective exposure, selective attention, perceptual defence and perceptual blocking. People usually perceive those things that they need and want, and block the perception of unnecessary, uncomfortable or painful stimuli. Consumers organize their perceptions into unique units in accordance with the principles of Gestalt psychology, namely: the relationship between the figure and the background, grouping and rounding off the whole. The interpretation of stimuli is highly subjective, and is based on what the consumer expects to see in the light of previous experience, on several convincing explanations that he can imagine, on motives and interests during perception, and on the clarity of the stimulus itself. Consumers often evaluate the quality of a product or service based on a range of information; some are intrinsic to the product (eg color, size, taste, aroma) and others are extrinsic (eg price, image, stores, brand image, ambience in which the service is provided). In the absence of direct experience or other information, consumers often rely on price as an indicator of quality. How the consumer perceives the price - as high, low or fair - has a strong influence on the purchase intention and satisfaction with the purchase. Consumers' ideas are not limited only to the perception of the price and image of the store, but also extend to the manufacturer himself. Manufacturers who enjoy a good image find that their new products are more readily accepted by consumers than those from manufacturers with a less favourable or even "neutral" image [2].

4.1. Advantages of digital marketing

Once upon a time, marketing simply meant advertising, and advertising was once a must address the masses. Advertising relied on sudden intrusions that would force people to they pay attention to some message, which they don't really expect or look for at that moment. Also, advertising was one-way: from the company to the customer, and it was dealt with exclusively by selling products and was based on campaigns of limited duration, and creativity was considered the most important component of advertising. All that together today it is no longer valid. The Internet has changed the rules, and now marketing must change as well in order to make the most of the offered online marketplace of ideas.

A great advantage of digital marketing is the greater ability to monitor the success of campaigns and activities and a much lower cost of promotion. The advertiser can track everything on a daily basis relevant statistics on visitors to your website and on individual customers product or service, and at any moment he knows whether an individual investment is worth it and in accordance with that, it is possible to terminate campaigns that do not achieve in time satisfactory return. With all that, digital

marketing can reach globally, the possibility of constant advertising - 24 hours a day, 7 days a week and constant improvement through new trends. It has the advantage of mass customization of products to clients (different products and messages to different stakeholders) and has an advantage personalization. Also, e-marketing reduces costs - cheap distribution communication messages (for example e-mails) and cheap distribution channels for digital products. It is currently the most effective form of advertising in the world. Benefit from of digital marketing are immeasurable: from achieving interaction on a large number contacts between the consumer and the brand to a better understanding and satisfaction of needs customers by their location, the device they use or the time of day they are most open for advertising messages. One of the biggest advantages of digital marketing is that it can be done all activities can be monitored and measured.

Mobile marketing enables simple and fast two-way communication between the brand and the consumer at any time of the day and from any place, because it's mobile phones are highly personalized devices that are completely tailored to the needs and habits of its users. The mobile phone is always with its owner, wherever he is. Mobile marketing provides great opportunities for targeted advertising according to demographic data, locations and consumer habits, and it can be realized through SMS, MMS, creating mobile applications, developing mobile websites, by delivering mobile coupons and the like.

There is also advertising according to the user's location, the full name of which is "location-based." advertising" or LBAF. It is a form of direct marketing that integrates mobile advertising with location-based services. Using technology, locating is done consumers to be shown location-specific ads on their mobile phones. On the therefore, advertisers are able to locate consumers who are near them point of sale and provide them with a relevant and up-to-date commercial offer.

5. Digital marketing strategies in the interaction of market supply and demand

There are many digital marketing strategies that companies use to reach their customers and ultimately develop relationships with them. Some of the most important strategies that will be discussed in the following chapters are: content marketing, conceptual advertising, website analysis, marketing strategy in relation to the product, marketing strategy in relation to the target market, and marketing strategy in relation to the media of advertising and communication.

Apart from the mentioned strategies, there are many more strategies that companies use in their marketing, and these are often strategies adapted for that particular company, just as every other strategy must be adapted to the needs of each individual company. The goal of marketing strategies is for companies to implement marketing activities as quickly and as simply as possible, which will help achieve the goals of the company. That is why it is important to know well which strategies exist, what their benefits are and how to implement them, which follows below.

Content Marketing – As a young marketing strategy, content marketing has not yet developed a concrete definition. It is a strategy that has only just begun to be recognized and used in marketing, and it will take time when different experts and authors begin to come up with concrete definitions for content marketing. Until then, content marketing can be described as a digital marketing strategy that tries to reach customers and create relationships with them through different, impactful, interesting and often useful texts. In English it is called content marketing, while in Serbian there is still no correct, generally accepted word, but it is most often called content marketing or content marketing.

Nowadays, many marketing agencies also provide the service of content marketing, which is becoming more and more popular over time and is in great development. On its website, the marketing company defines content marketing as an ideal strategy that demonstrates the professionalism of the business to existing and potential clients, and thus also provides confidence in the purchase of products/services offered by that company. Content marketing services include the creation of creative new content, as well as the optimization of existing content. Content marketing is not only used on web pages as it is usually linked, but also through social networks, e-mail marketing and advertisements. This marketing agency also states that the importance of this strategy lies in teaching clients about the services, products and ways in which the company operates, which builds trust and creates quality and long-term relationships with customers.

Although blogs are quite outdated because they have been overtaken by social networks, there are still people who like to follow a good blog, so some companies have a blog within their websites where consumers can read interesting and useful content that may encourage them to buy, and along the way they can and participate in the communication itself. Then there are long-form contents that are mostly in the form of guides that provide more useful information and instructions about the product/service that the company offers, which is a big advantage for that company. Furthermore, e-books in general have become very popular in the last few years because they provide simplicity and are a cheaper choice for people who like to read a lot. In the case of e-books for content marketing purposes, they are like manuals of up to thirty pages, and are most useful for more complicated products and services that require more instructions and information. Case studies are research that provide solutions to set problems, goals and hypotheses, and they can be very useful in marketing because they show the seriousness and value of the company. The fifth example of content marketing includes infographics, and it refers to the interesting visual presentation of various, mostly statistical data

Contextual advertising - Internet search engines have become the main tool for consumers to locate information, which is why Search Engine Marketing (SEM) was born and developed, which includes paid or sponsored search [1]. In other words, companies pay to be more visible on the first pages of Internet search engines.

Search Engine Marketing (SEM), i.e. contextual advertising, refers to advertising on search engines. On the most famous search engine - Google, this method is called Google AdWords. This platform is the largest advertising platform used in digital marketing and through it the most online purchases are made in the world [4]. Therefore, for consumers, the Internet has become the main way to information, which is why Internet pages are filled with various information and content. This led to the development of a tool that makes it easier for companies to stand out from others - SEM, and Google accordingly developed Google AdWords.

Google, as the most famous internet search engine in the world, has developed the Google AdWords tool, [4] and its advantages for web traders are as follows:

1. Ads are targeted and timely,
2. you choose the keywords yourself,
3. you don't pay to display ads on Google,
4. you can see every click and every sale,
5. you can optimize each Google Ad Words campaign yourself

This is one of the main strategies and tools that today's modern companies use in digital marketing, considering that it makes it much easier for consumers to search, but also for companies to get customers to their websites. This strategy leads to the next chapter, which is about website analysis itself, and these two strategies are interrelated since they both involve company websites.

Website Analysis - When a company creates and maintains a website, it incurs high costs for its creation and maintenance because it requires continuous maintenance, changes and adjustments. For this reason, it is important to analyze its effectiveness so that the company can see if the website serves them, or if it is just an unnecessary expense. Therefore, from the possibilities listed, it can be concluded that it includes data on the number of visitors and their characteristics, on the channels that led them to the website, which content they like the most and what their preferences are, and so on. Therefore, it is evident that the company uses this tool to obtain extremely important information, which then leads the company to changes in business, to the introduction of new processes, content or even products and services. This is important information because today there is a lot of competition on the market in almost all branches, which is why it is not enough to just have a good product or service, but the market requires much more effort and investment in order for consumers to recognize companies, their products and services.

Marketing strategy in relation to the product - In order to be able to talk about marketing strategies in relation to the product, it is first necessary to connect it with the growth strategy because the goal of all marketing is the growth of product/service sales, the growth of the brand and popularity, and ultimately the growth company income. Often, the quality of the product alone does not guarantee the success of that product on the market, mainly because of the great competition nowadays, but good

marketing strategies can position it high on the market. For this reason, there is a great connection between marketing and the product itself, because marketing would not exist without the need to advertise the product, nor would the product survive on the market without good marketing, and they are closely related to each other.

Marketing strategy in relation to the target market - The market that the company targets depends primarily on the products and services it offers because different cultures, religions, customs, financial capabilities of consumers, different wants and needs are found in different markets, but it also depends on the competition. , that is, market saturation with those specific products or services. Therefore, marketing activities and strategies must be adapted to the market in which they appear, that is, they must choose carefully which market they will try to enter. In fact, we can talk about target marketing here because the target market is part of the tasks of target marketing.

When choosing a product, they often perceive risk due to uncertainty about what the consequences of their decision will be. The most common types of risk perceived by consumers are: functional, physical, financial, social, psychological and time risk. The consumer's strategies for reducing perceived risk include increased search for information, loyalty to one brand, buying a well-known brand, buying the most expensive brand, and seeking guarantees in the form of money backs, guarantees and pre-purchase trials. The notion of perceived risk has important implications for suppliers, since by introducing risk-reduction strategies into their advertising campaigns, they can facilitate the acceptance of their new products.

6. Conclusion

The development of digital marketing has led to the need to adapt marketing activities, but also to different expectations from marketing. Given that digital marketing has the possibility of direct communication between companies and consumers, the marketing relationship began to develop, and at the same time, content marketing. In this way, the relationship between the company and the consumer is built. potential consumers interested in an interactive relationship, want as many opportunities as possible, information via the Internet. It is necessary to reach the consumer as much as possible, to see what his needs and desires are, and in this way to provide him with what he is currently looking for. An interactive relationship between consumers and providers would establish simple communication, where everyone would be approached individually in such a way that the producer is open to suggestions, advice, doubts and problems.

The consumer would feel satisfied, and the manufacturer could influence his final purchase decision at any time. The website prototype together with the research is proof that the market needs more of these or similar types of interactive relationship offerings. It is important to have as accessible communication as possible, visibility of the website, various activities on social networks. Feedback, experiences from others are important to consumers, such promotional messages need to be emphasized, highlighted, as well as any other qualities related to the product. In today's time, where the fast-paced lifestyle has become normal, an interactive website with as much necessary information as possible would save time and money for every consumer.

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Civilizational development of the script: RUNES

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Abstract: The word 'runes' originates from the Norse word *run*, which means secret, and the German word raunen (to whisper), but their origin has not been explained exactly to this day. It has been assumed that the Runes have evolved from older alphabets and were used by the Germanic and Nordic tribes of central and northern Europe. The script dates from the 3rd to the 13th century AD. Runes are script that mainly consisted of straight lines, designed to be carved into hard surfaces such as wood, stone, metal and bones. Throughout history, it was possible to find them on tombstones, swords, urns, shields and jewels, as well as on the household objects. There were three forms of the runic script: the Elder Futhark, the Younger Futhark, and the Anglo-Saxon Futhork. However, this script disappears in Central Europe, due to the popularity of Latin, which followed the spread of Christianity. Nowadays, runes are used for magic and divination, but this script remains as a model of success in the literacy of the nations, because it provides an insight into the world of ancient civilizations whose lives were uniquely rooted in harmony with nature and spirituality.

1. Introduction:

1.1 The history and origin

There are many theories about the origin of runes. Some of these theories have more followers than the others, but they all have one common issue, none can fully prove any of them. The first inscription on runes dates from the 1st to the 3rd century. Some assumptions are that the runic alphabet was created during the first century. The experts in the runic script agree that the runes have developed from an earlier script, one of which was the Etruscan alphabet.

The first theory implies that the geographical proximity of the Etruscans (who lived in northern Italy) with the Germanic tribes (in northern Europe) was possible only if these two nations had some form of cultural exchange, although there are similarities in some forms of the Etruscan and Runic script. The second theory of the origin of the runic script is Latin. The supporters of this theory believe that Germanic tribes were exposed to Latin through commercial contacts between Germanic tribes and the Roman Empire during the first century. They believe that Germanic tribes borrowed Roman letters and adapted them to their needs. The third theory is the legend of the Germanic tribes who also had their own interpretation for the appearance of runes, according to the legend of Odin (the supreme Norse god). The legend states that Odin, pierced with a magical spear (Gungnir), hung from the tree of the world (Yggdrasill) for nine days and nights as the living dead. This sacrifice brought him knowledge of the runes, which he passed on to humans.

The examples of runes carved into wood, stone and tombstone:

Figure 1. Runes carved into wood.

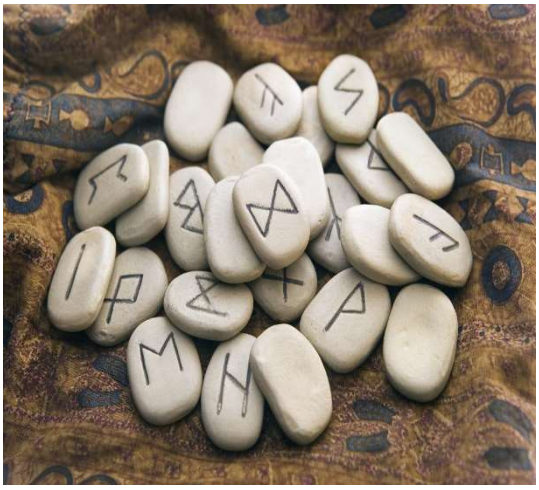

Figure 2. Runes carved on stones.

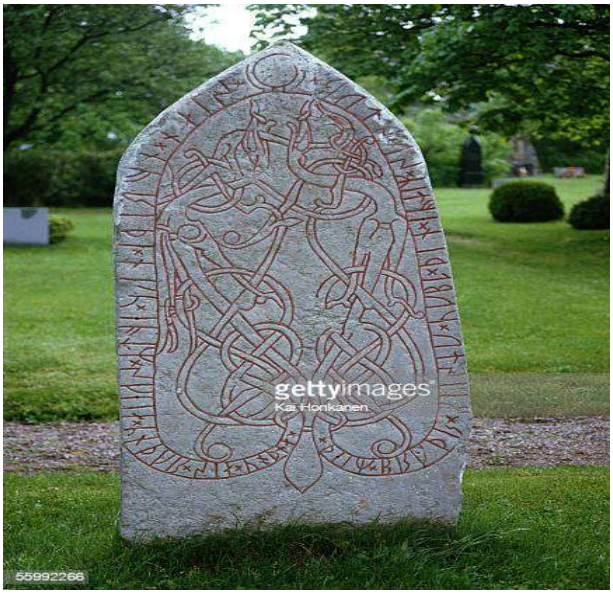

Figure 3. Runes carved onto tombstone.

2. Characteristics of the script

Runic script or Runic alphabet (futhark or fuþark - according to the order of the first six letters: (F U TH A R K) is a series of connected characters used as letters known as runes which were used by the Germanic languages.

There are no rules when writing runes. Runes can be written in different ways and on different materials, as a decoration or a hidden magical formula. When the runes were written on the rocks, it was necessary to carve many dots densely to get a complete line of the sign.

Runes could be written from left to right or from right to left. They can also be written so that the first sentence is written from right to left, and the second sentence from left to right (boustphedon). In addition, runes are sometimes written as a mirror image (venderuner), top-down (stupruner) or connected (bindrunes) such as the Norwegian Æ (+ E). Runes were often written in text form, without spaces between words or sentences. If one wanted to separate words or sentences from each other, a

notation similar to the letter X was used, or one, two or more dots written one above the other were used. If colons were used, then the sentence would look like this:
"I:WRITE:A:SENTENCE:WITH:TWO:COLONS".

Runes were all written with a capital letter, no lowercase letters were used in the runic script. Each rune not only represented a phonetic voice, it also had its own meaning, often associated with Norse mythology. The scientists believe that the Germanic nations used runes originally as a means of communication, and only later for magical purposes. As the Proto-Germanic languages later developed into other language groups, the word and sound represented by the runes began to change so that each culture either created additional runes or disposed of a certain symbol from their alphabet.
From the basic runic alphabet, other forms of the ***futhark*** were further developed in history, but of all the forms, three systems of symbols remained recorded in the runic script.

3. Variations of the Runic script through the history

The runic system is dynamic, flexible and creative, for these reasons every culture or nations had ways to adapt the runic script and writing system to themselves and their needs. Through centuries of use of this "Western" system of symbols, three basic runic sequences have been developed: Old Futhark (Elder Futhark: 24 runes), Anglo-Saxon Futhorc (Anglo-Saxon Futhorc: 29-33 runes) and Younger Futhark (Younger Futhark: 16 runes) The last two were derived from the first, oldest alphabet - the Elder futhark, which consisted of three groups, called aetti (families). There are eight runes in each aett of the Elder futhark, arranged to reflect the very core of the Science of Runes.

3.1 Elder Futhark (2nd-8th century AD)

The earliest known sequence of a complete set of 24 runes dates back to around the 4th century AD and was found on Kylver Rock in Gotland, Sweden.

Figure 4. Kylver rock, 4th century AD, Gotland, Sweden.

The Elder futhark, which was used to write Proto-Norse, consists of 24 runes that are often arranged in three groups of 8 runes each; each group represents one aett. Each rune has its own name, chosen to represent the very sound of a rune.

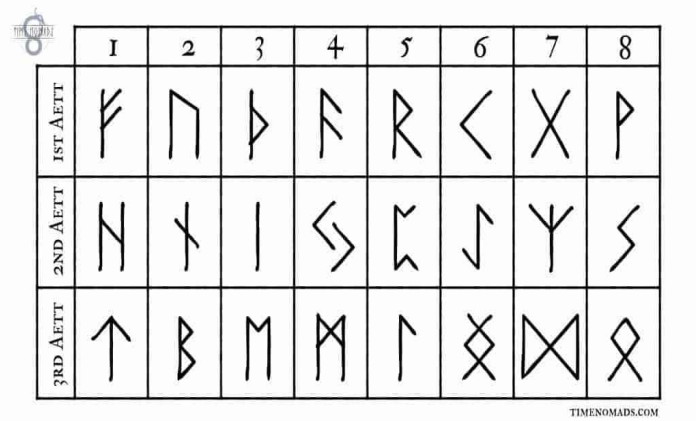

Figure 5. Three groups of 8 runes, each row represents one aett.

The three aettas presented in Figure 3 are described and interpreted as follows:
Frey's first aett:

Fehu f - movable property, money, cattle
Uruz u - strength, health, wild bull
Thurisaz th - luck, demon, thorn
Ansuz a - blessing, communication, language
Raido r - journey, change, wheel
Kaunaz k - light, opening, torch
Gebo g - abundance, merger, gift
Wunjo w - happy ending, joy, companionship

Second Hagal aett:
Hagalaz h - past, misfortune, fight
Nauthiz n - future, anxiety, night
Isa i - present, obstacle, ice pillar
Jera j - harvest, deserved, year
Eihwaz æ - turned, business, yew
Pertho p - hidden, birth, vice
Algiz z - protection, striving, moose
Sowulo s - complete, success, sun

Tyr's third aett:
Teiwaz t - victory, sacrifice, leadership
Berkana b - spring, saplings, birch
Ehwaz e - pair, action, horses
Mannaz m - man, society, mirror
Laguz l - woman, intuition, water
Inguz ng - fertility, peace, hearth
Dagaz d - prosperity, spirituality, light
Othila o - inherited, tradition, nobility

Elder futhark was primarily composed of 24 symbols, starting with **F** and ending with **O**. It was mostly used by northern Germanic tribes in the areas of Sweden, Denmark and northern Germany. In some literature, this type of rune is also called the Germanic futhark.

3.2 Anglo-Saxon Futhorc (5th-11th century AD)

Futhorc is a derived rune system from the old Futhark. This system primarily consisted of 29, and later even 33 symbols. It was most likely used since the 5th century AD. There are two opposing theories of the origin of the Anglo-Saxon fuþork. The first theory proposes that this script developed in Frisia and later spread to England. The second one holds that the Scandinavians brought the futhark to England, where they modified it for their needs and later transferred it to Frisia. Both of these theories have their weaknesses and the definitive answer to this issue can only be found by archaeologists in new evidence. Futhork inscriptions were found on the Thames scramasax (9th century knife, fig 6.) and on the Franks Casket (7th century casket, fig 7. and 8.).

Figure 6. Seax of Beagnoth, also known as Thames scramasax, 9th century.

Figure 7. Franks Casket, 7th century.

Figure 8. The left side of the Franks Casket with inscriptions on futhorc (Anglo-Saxon runes).

In England, the old futhark was modified in its final limit to 33 letters to accommodate the changes that occurred in Old English, the language spoken by the Anglo-Saxons, although some books also mention 31 symbols. Even the name of the new alphabet "Futhork" is evidence of a phonological change, where the long vowel /a/ changes to /o/ in Old English. The new letters compensated for the sound change in Old English. If one sticks to the claim that the futhark developed into 33 symbols, the following image shows all 33 letters of the Anglo-Saxon alphabet:

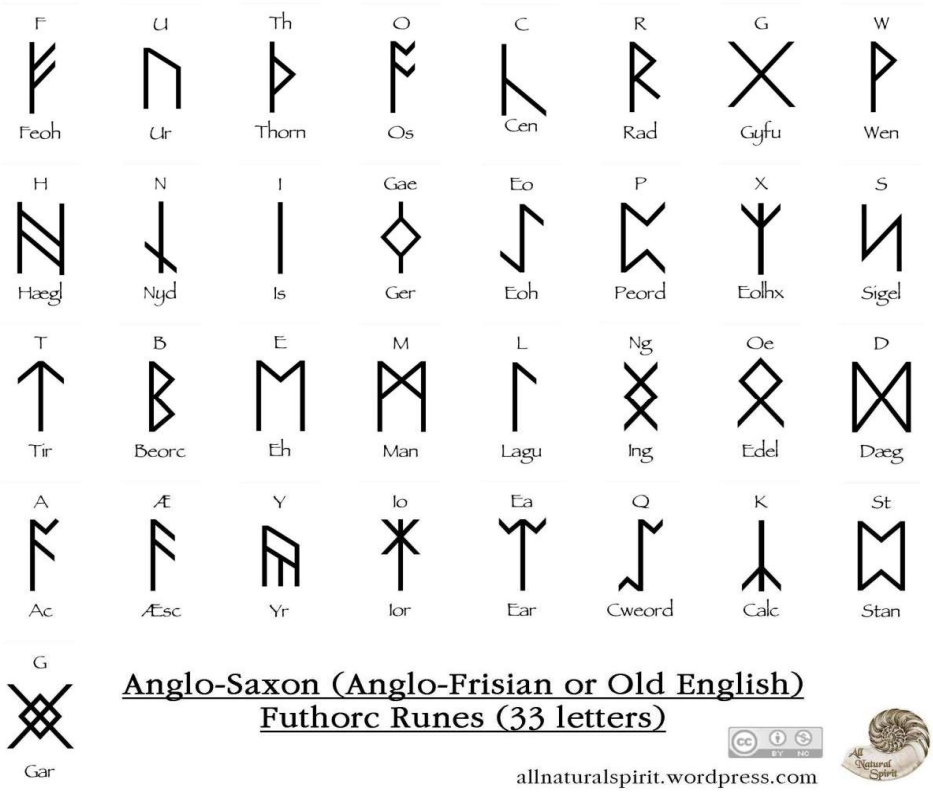

Figure 9. Anglo-Saxon Futhorc.

Three important changes in the runic script of the Anglo-Saxons:

1.In Old Futhark, the letter k became the letter c in Futhark, which was pronounced as /k/ before the vowels /a/, /o/, /u/, and as /c/ before the vowels /e/ and /i/, so the new Futhork letter k was created to represent the /k/ sound regardless of accompanying vowels.

2. Similarly, the letter g in the old Futhark represented /g/, /y/, and /gh/, and another g was introduced which would constantly represent the sound /g/.

3. In Old English many vowels were raised and for this reason new letters were created for vowels. Due to changes in the language, it was necessary to add or introduce new runic letters A/O, C/K, H, J, S, and Ng. Precisely because of the language in which it was used and the needs of that language, five to nine runes were added to the new Anglo-Saxon Futhork system.

3.3 Younger Futhark (9th-11th century AD)

The Younger Futhark, also called the Scandinavian Futhark, is a reduced form of the Elder Futhark and consists of only 16 letters. In Scandinavia, the Elder futhark was used until about the 8th century (in the times of the Eddas). A big change in the Old Norse language occurred accompanied by the changes in the runic alphabet to adapt the runes to certain sounds. Unlike the Anglo-Saxon runes, these new Younger Futharks reduced their number from 24 to 16, and some runes were used for more sounds. The

shape of the rune was also changed and simplified. This reduction in the script was due to a phonetic change from Proto-Norwegian to Old-Norwegian.

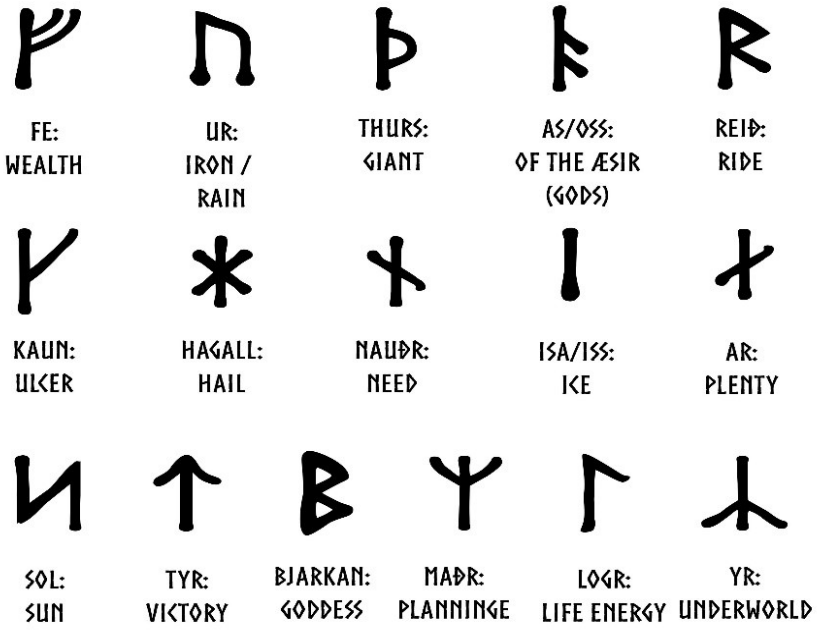

Figure 10. Younger Futhark.

Nine of the authentic letters of the Elder futhark were omitted as well (**g, w, æ, p, z, e, ng, d, o**), but one new letter (**R**) was created. The reason for this reduction in the letters in the Younger Futhark was related to the very complex phonological changes that occurred in the Old Norse language. Some of the old letters were removed from the alphabet, but some of the letters also took on the role of polyphony, namely:

- **th** was used for /þ/ and /ð/;
- **u** for /u/ and /o/;
- **k** for /k/, /g/, and /ng/;
- **i** for both /i/ and /e/;
- **t** for /t/ and /d/;
- **b** for /b/ and /p/.
- A new letter, **R**, was used for the /er/ sound in Old Norse, but later became /y/ in later Scandinavian languages.

Inscriptions of this script have been found in the area of Scandinavia and Viking dwellings outside these areas.

Figure 11. Rock drawing near Rasmund, Södermanland, Sweden.

There are several variations of this runic script, Danish (long-branched) and Norwegian (short-branched). The difference between these two variations is a matter of controversy. The general opinion is that the difference was functional, i.e. the long-branched one was used for documenting on rocks, and the short-branched script was used in everyday use for personal and official messages on wooden material. The visual difference in these two scripts variations is shown in figure 12.

Figure 12. Difference between long-branched (Danish) runes and short-branched (Swedish-Norwegian runes).

This form of the runic script spread from Denmark to the north into Sweden and Norway and was taken to Iceland and Greenland by the Vikings. It is possible that they have also brought it to the soil of North America during the Viking expeditions. Although the Futhark continues to live on as a writing system, it began to disappear with the spread of the Latin script. In England, the Anglo-Saxons began to use the Latin alphabet and rejected the Futhork as early as the 9th century AD and it did not even survive for long after the Norman conquest in 1066. Futhark continued to be used on the soil of Scandinavia for centuries, but by the 1600s it became more of a curiosity among scientists and antiquarians.

4. Runic calendar

The runic calendar is a calendar based on the 19-year metonic cycle of the moon. In some literature, it is referred to as the Runic Staff or the Runic Almanac. It is assumed that it originates from medieval

Sweden. In the beginning of the use of this calendar, it was written on parchment or carved into sticks made of wood and bone. The oldest known and the only one from the Middle Ages is the Nyköping baton, which is believed to date from the 13th century.

Figure 13. Runic calendar - Norwegian – carved wood.

The most of the calendars that have been preserved originate from the 16th and 17th century. During the 18th century, runic calendars had a renaissance, so at that time they were made of brass. A typical runic calendar consisted of several horizontal rows of symbols, one above the other. Special days such as solstices and celebrations (including Christian holidays and feast days) were marked with additional rows of symbols. The calendar does not rely on knowledge of the length of the seasons or the occurrence of leap years. It would be set at the beginning of each year by observing the first full moon after the winter solstice (short day). This first full moon also marked the day of Disting, a pagan holiday and fair day.

5. Modern use of the runic script

The runic script has seen a variety of uses since the 18th century, so it was used in Nazi Germany in the 20th century, in the fantasy genre and for magical purposes.

5.1 Nazi Germany

Runes were used in Nazi symbolism by Nazi groups associated with the Germanic tradition. The runic script has seen a variety of uses since the 18th century, so it was used in Nazi Germany in the 20th century, in the fantasy genre and for magical purposes.

Runes used in Nazi symbolism by Nazi groups were associated with the Germanic tradition. Mostly these were Sig, Eihwaz, Tiwaz, Odal and Algiz runes.

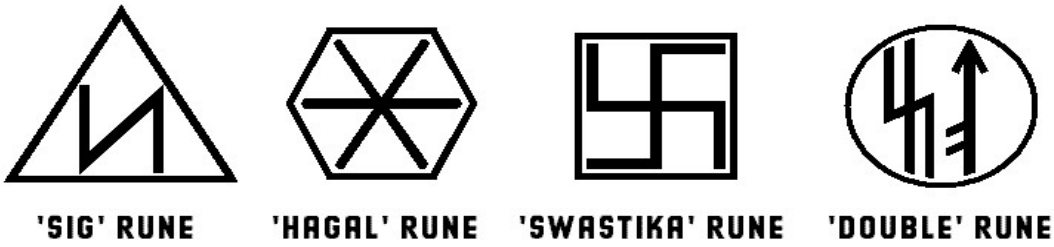

Figure 14. Symbols used by Nazi Germany.

These runes were worn by SS followers on rings in combination with a skull.

In the literature, the above mentioned runes are interpreted as follows:

1. Sig rune – when one sig rune is placed to the left and one to the right of the representation of the skull, framed by a triangle, then they represent lightning or a flash, i.e. the power or strength of the SS (shield division-brigade of the Nazis).

2. Hagal rune - (framed hexagon), represents the faith and camaraderie idealized by the leaders of Nazi organizations. The meaning of this rune was interpreted by Hagal according to Guid von List: "Encompass the cosmos/world within you and you control the cosmos/world".
3. Swastika – framed in a square. It comes from Sanskrit, the meaning of the word is happiness, auspicious object, and especially a sign that is placed on a thing or person to predestine it to happiness. Members of the SS used the swastika as an influential symbol of the strength of the Aryan race.
4. The double runes on the back of the ring framed in a circle denoted the "heilszeichen" (sign of salvation). These runes were not created by SS followers but had a historical connotation. They are painted as a double "sig" rune and a "tiwaz" rune. *Sig* rune had the meaning of the sun, while *tiwaz* was interpreted as the rune of battle, force and power.

5.2 Literature genre – Fantasy

In the novel by J.R.R. Tolkien's "The Hobbit" (1937), Anglo-Saxon runes were used on the cover of the book but also on the map in the book describing the dwellings of the dwarves. They were also used in the initial drafts of The Lord of the Rings, but were later replaced by the Cirth rune-script invented by J.R.R. Tolkien.

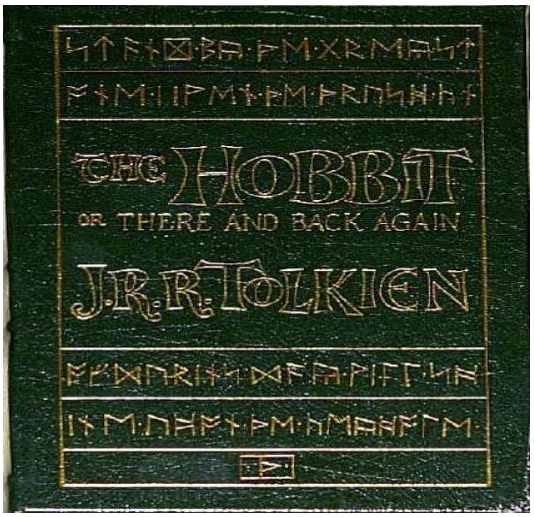

Figure 15. Display of runes on the Hobbit book.

Figure 16. Cirth script - invented by JRR Tolkien. book cover

After Tolkien, historical and fictional runes appear commonly in contemporary popular culture, especially in fantasy literature, video games, and various other forms of media. For example, Hermione Granger learns the ancient runes in J.K. Rowling's book, "The Half-Blood Prince" - part 6 of the Harry Potter books. There are also video games on the topic of using runes and their meaning to move to different levels in the game.

5.3 Ritual function of runes – Magic

From the beginning, runes have taken on a ritual function, used for prophecies, divination or spiritual orientation in which higher powers were invoked that could influence people's lives and happiness.

The skill of the runic masters touched every aspect of life, from the sacred to the most practical parts. There were runes and spells that affected the weather, tides, harvest, love, health, fertility, birth and death. Runes were engraved on talismans, mugs, spears, huts and ships. Twigs and stones were used in runic divinations because, as natural objects, they embodied ancient powers. Runic symbols were carved into pieces of wood, pressed into metal, or carved into skin that had been soaked in human blood, which was thought to enhance the spell's potency. Most often, they were on the smooth surface of pebbles with symbols drawn on one side. The runic masters had bags containing these stones, each with a rune on it. They would shake the bag and throw them on the floor. Those runes that fell with the symbols facing up were then interpreted.

Figure 17. Runes on stones.

Figure 18. Runes on wood.

Runes were the ultimate magical tool for rituals with Norse deities. Each runic symbol contained an elemental force that corresponds to the characteristics of a God or some natural power. Each rune was both, a letter and a carrier of natural potency. Runes were the heirs of shamanic symbols of power, whose roots went deep into the past before the beginning of the alphabet itself.

6. Conclusion

Runes were created around 100 - 200 AD among the Goths and other Germanic tribes located in the area north of the Black Sea. Later, the runes spread throughout central and northern Europe through the migration of these tribes. Runes were used by the Goths, Germans and Frisians in southern and central Europe and by the Anglo-Saxons in the west. In the north, they were used by Norwegians, Swedes and Danes, as well as in Iceland, Greenland and the Lapps (Sami). Until the year 300, the runic alphabet was the only alphabet used in Scandinavia. Runes were used in documents, songs, magic, witchcraft, usually carved into jewellery and weapons for their protective powers. Each rune, apart from its literal meaning, had a story attached to it related to Norse mythology. There were three forms of the runic script. The oldest and most commonly used form is the Elder Futhark, which consisted of 24 symbols. The Younger Futhark, which developed later, when the runic alphabet spread to the north, was reduced to 16 letters. Third, the Anglo-Saxon Futhork, was expanded to 33 letters. This last form was due to settlement on the soil of Britain by Germanic tribes, so there was also a change in the runic script to meet the needs of the new language. The runes were able to go deep into "foreign" territories, so the alphabet was also found on a monument in the ruins of a church from the 6th century in Breza (Bosnia and Herzegovina). However, Latin over time completely suppressed them. The non-Latin scripts of the Europe retreated before the spread and use of Latin script. The Roman army had already spread that system across the European continent and across Britain, but it was precisely the spread of Christianity and the high reputation of the Latin language and script that would eventually lead to the loss and disappearance of the runes. Nowadays, runes are used for magic and divination, but this script remains as a model of success in the literacy of the nations, because it provides an insight into the world of ancient civilizations whose lives were uniquely rooted in harmony with nature and spirituality.

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Project management

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Abstract. Technical and technological innovations, contemporary economic trends and scientific achievements constantly bring changes to which we must all inevitably adapt. New trends and changes are continuous and dynamic, so they bring numerous challenges for companies, institutions, and all other types of organizations. Nowadays, organizations are more successful if they can quickly respond to changes and adapt to dynamic environment. One of the significant responses of modern managing to constant changes is project management. Project management is a multidisciplinary approach to managing organizational capabilities and techniques in order to achieve specific goals. The intention of this paper is to present the concept of project itself, to give an overview of project management significance and the most common tool (logical framework matrix) for implementation and successful project management.

1. Introduction

Nowadays, organizations have to adapt much faster to the challenges from dynamic environment. Regardless of whether they are trying to maintain their local or regional positions or their growth is imperative, organizations encounter constant problems of managing and scarce resources. Insight into the current state is sometimes impossible, business is chaotic, and the results are often uncertain. Project management enables continues adaptation as a respond to constant changes. In order to define project management in general, this paper will first define what a project is and what are the characteristics and types of projects. Project management represents applied knowledge, skills, tools and techniques for project activities in order to reach the goals and requirements set by the stakeholders during the preparation of project. The 7–S framework clearly shows the very essence of project management, and, also allows the classification of project management tasks, which significantly reduces complexity. The project life cycle plays also a significant role in this, which greatly helps in the division of tasks, reporting and control of the project and its activities. In perfect circumstances, the project manager will do all the necessary work of a particular phase before moving on. However, the circumstances, mostly, are not perfect and project success often requires a flexible approach that corresponds to the real life and business situation. Except the 7-S framework and the project life cycle, one of the most important elements for successful project management are project management tools, and one of the most common is the logical framework matrix.

2. Concept and characteristics of projects

A project could be any activity with precisely defined beginning and end in order to achieve specific objective. The projects could be: launching a new product or service, construction of road or building, development of an information system for various purposes, organizations of events etc. There are many activities in common life that could be defined as a project, like a wedding, organizing a birthday party, a trip, if these events are timed and organized with a precise goal.

2.1. Project definition

Thera are many definitions of project. Harvey Maylor in his book „Project Management“ gives a few definition of project [1]:

- "Association for Project Management (UK's largest professional body for project managers), 2004: Projects are unique, transient endeavors undertaken to achieve a desired outcome.
- Project Management Institute (world's largest professional association), 2004: A project is a temporary endeavor undertaken to create a unique product, service or result.
- British Standard 6079, 2000: A unique set of coordinated activities, with definite starting and finishing points, undertaken by an individual or organization to meet specific performance objectives within defined schedule, cost and performance parameters.
- PRINCE 2 2009 (PRojects IN Controlled Environments – UK government standard for project management), A management environment that is created for the purpose of delivering one or more business products according to a specified business case. And: A temporary organization that is needed to produce a unique and predefined outcome or result at a given time using predetermined resources.
- Project Management Association of Japan, 2005: A project refers to a value creation undertaking based on a specific mission, which is completed in a given or agreed timeframe and under constraints, including resources and external circumstances."

Common characteristics that are repeated can be observed in the above definitions. They are primarily reflected in the uniqueness and innovation, that is, in the fact that it is a separate activity that has not been carried out until now, and a certain space, budget and team of people who will realize it have been provided for. The second characteristic refers to the time frame, defining the beginning and end of the project. A certain organization and a team of people are established who are in charge of implementation for each project. The financial resources available to the project are also temporary and provided for a specified time frame. In addition, each project has a concrete goal that it wants to achieve, that is, a purpose for which it is realized.

2.2. The difference between a project and a process

It is important to know the basic difference, but also the overlap between the project and process in order to define the context of project management. Work in the organization was traditionally divided into projects and processes or work operations. Today, in modern economic business practice, they often overlap because processes and projects share many common characteristics [2]:

- they have a goal and purpose,
- they are performed by the people,
- they have limited resources,
- they are planned, implemented and controlled.

The term project is used to describe activities that organizations do not perform every day, but such activities are performed periodically and as needed. Therefore, they are unique and temporary. The term process implies a set of everyday activities of an organization that continuously and routinely transform certain organizational inputs into desired outputs [2]. In essence, a process means a series of repetitive activities. Furthermore, the process does not have a defined end or specific objectives, but only clearly defined tasks and work activities.

2.3. The characteristics of projects

The common characteristics of projects can be specified based on different definitions. The project [2]:

- is a temporary undertaking that has a beginning and an end,
- has a unique product or service as a result;
- is a one-time and each is with its own defined goal and intention;
- is directed towards a specific, previously defined goal;
- has its own budget;
- contains a timeframe of activities, i.e., development phases that make the life cycle of the project;
- presents the ability of the project manager and donors;
- focuses on quality;
- has its own structure;
- transforms the existing state into the future, desired one.

There are few common characteristics of projects. First, there is an emphasis on time determination, the beginning and the end of the project are clearly defined. This does not necessarily mean that projects last a short time - some projects can last for several years. Projects end when previously specified goals are met, i.e., when the desired result and purpose of starting the project is achieved. However, during the implementation of the project, it can be determined that there are no conditions for the full implementation of the project and that the ultimate goal cannot be met. The reasons for this can be wrong estimates, improper project management or changes in the environment that cannot be acted upon. These are also situations when the project comes to an end. The project can be also ended when it is determined that its results are no longer necessary.

In addition, projects are based on a certain transformation, that is, they turn certain inputs into outputs through project activities. This transformation is conditioned by various factors that can be grouped as follows [2]:

- INPUTS – Every project starts with the certain needs or desire, i.e., with the lack that is sought to be compensated for. This is how an idea emerges, which is one of the basic inputs.
- OUTPUTS – The final goal of the project, which implies the satisfaction of a need that was initially defined as a lack. Therefore, new products or services are created as the results of the project, but also knowledge bases are additionally created for use even after the end of the project.
- CHALLANGES AND LIMITATIONS – Projects are realized within the framework of certain challenges which are placed in front of project managers and project team as well. These limitations could be financial, technological and/or legal. Every project has a certain budget for implementation and its distribution is according to the plan. Time is also already mentioned limitation as well as legal regulation limitations. Besides these, there are influences from environment such as economic and political factors on which we do not have any impact.
- RESOURCES – enable the implementation of project activities. They include the people – project implementation team, project manager, as well as all implementation tools (facilities, communication channels, knowledge bases etc.)

2.4. Types of projects

The determination of project types can be made in relation to several determinants, concerning very broad application of projects and inclusion of different segments of business and life generally. Several types of projects are listed below, which are divided according to different criteria. In relation to the type of activity, we can determinate following types of projects [3]:

- Technical projects – are aimed at creating a physical project product with clearly defined technical elements.
- Economic projects – are aimed at economic development, increasing company profits and creating added value by strengthening competitive advantage.

- Social projects – do not necessarily bring profit, but they contribute to the development of society and community, strengthen interpersonal relations, and influence the improvement of living standards.
- Educational projects – enable the expansion of knowledge and abilities, but also the practical application of learned elements.
- Investment projects – are characterized by the size of the investment, as well as a certain degree of risk.
- Mixed projects – include several elements from the previously mentioned types.

The following types of projects can be specified when it comes to the nature of the activity is taken:

- Research projects – include, by their nature, research as well as determination of the importance of the problem, parameters, purpose of the study, hypothesis, task, methodology. In addition, they include collecting and analyzing information, conducting experiments, developing practical solutions.
- Creative projects – are focused the development of new original ideas or products, joint activities presented in a creative way, for example conceptual projects of new products.
- Information projects – aimed at collecting information. The result of the project is selected, analyzed, generalized, systematized, and presented in a certain form of information, for example, brochure, publication, website and similar.

There are different types of projects in relation to the duration of projects:

- Short-term projects – last up to one year.
- Medium-term projects – last from one to three years.
- Long-term projects – lasting over the three years duration.

We can also classify projects in relation of geographical spread and representation:

- Local projects – all project participants are located, for example, in one city.
- Regional projects – project participants are located in one region.
- International projects – project participants are located, for example, in several countries.

Within one company, projects can be implemented only in certain departments or functional units, but also in the area of the entire company. Accordingly, projects can be:

- local – in the area of one segment, functional unit or subsidiary; and
- corporate – in the area of the entire company.

3. Concept of project management

Nowadays, organizations are more successful if they can quickly respond to changes and adapt to dynamic environment. The same could be applied to projects. Project management faces complex challenges. The rapid development and spread of technological achievements and thus, also, the speed of changes in the market, have created great burdens and challenges for existing forms of organization. The traditional organization could no longer react quickly enough to the changing environment and adapt to it. Therefore, it was gradually replaced by project management, or other temporary management structures that are highly adaptable and can react very quickly to developments inside and outside the company.

3.1. Project management definition

Project management is applied knowledge, skills, tools and techniques on project activities in order to reach the goals and requirements set by interest-influential groups during the preparation of the project [2]. The core of project management includes planning, organizing, monitoring and controlling all aspects of the project, and motivating all involved participants and stakeholders to achieve project goals safely, within the planned budget, time and other set performance parameters [2]. All activities are performed within certain limitations. Therefore, the set goals are achieved through implementations of activities with the use of limited resources and time.

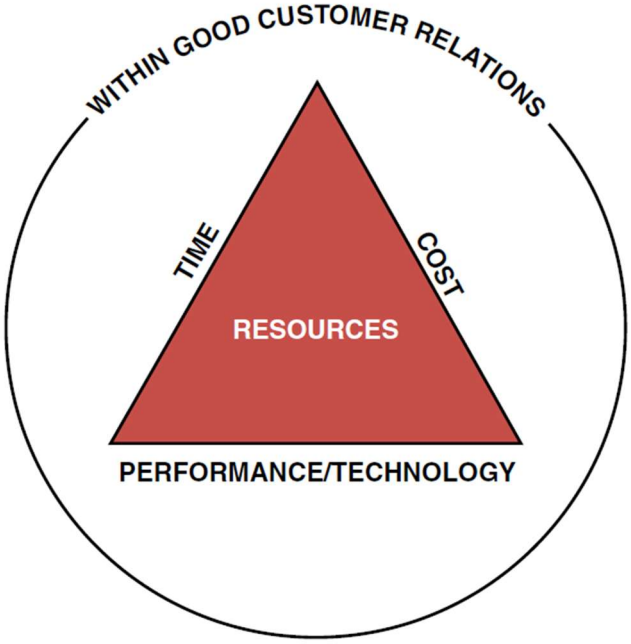

Figure 1. Overview of project management.

Figure 1 [2] shows a simple project management model. The purpose of this figure is to show that project management is designed with the ability to manage company resources on a given activity, within a certain time frame, cost frame, and given effects. Time, cost, and performance presents project limitations. There could be, also, the fourth limitation if the project is done for an external client, and it implies as custom relationship management.

3.2. 7-S of project management

Project management faces numerous complexities and influences. There are various approaches that facilitate these complexities and influences, and help successfully implement projects. One of the them is the 7-S framework approach which provides a comprehensive set of issues that needs to be considered. It also allows classification of tasks which reduces the complexity of the project management. In addition, classifying issues in this manner ensures that the project manager will know where to look to find sources of help if novel situations arise. The 7-S framework of management issues was promoted by McKinsey and Co., management consultants [1]. This framework includes seven elements: strategy, structure, systems, staff, skills, style/culture, stakeholders, which helps in understanding the fundamental determinants of project management. The following table 1 [1] presents the elements and their meaning.

Table 1. The 7-S of project management.

Element	*Description*
Strategy	The high-level requirements of the project and the means to achieve them
Structure	The organisational arrangement that will be used to carry out the project
Systems	The methods for work to be designed, monitored and controlled
Staff	The selection, recruitment, management and leadership of those working on the project
Skills	The managerial and technical tools available to the project manager and the staff, and how these are developed
Style/culture	The underlying way of working and inter-relating within the work team or organisation
Stakeholders	Individuals and groups with an interest in the project process or outcome

3.3. Life cycle of project

One of the basic characteristics of projects is temporality, i.e., time defining and limitation. Accordingly, the project has its beginning and end or it can be simply said that the project lives and die. Numerous authors highlight several phases of the project's life cycle, and there is a discrepancy in the number of phases the project goes through. However, basically, every project has a beginning, an implementation, and an end. Heagney J. in Fundamentals of project management shows the project life cycle through five phases: concept, definition, planning, execution, and closeout [4]. According to this model every project starts as a concept, which is always "vague" and the project team must formalize the job definition before starting the project creation. The following figure 2 presents Heagney's project's life cycle [4].

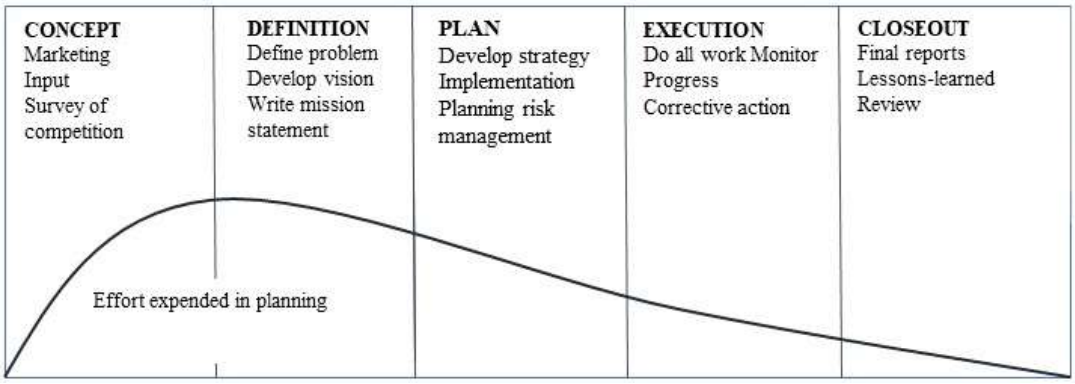

Figure 2. Project life cycle.

Figure 2 shows that the greatest effort is actually invested in the process of defining goals and objectives, and planning activities.

Project Management Tools are the munitions that project managers require to help a team or an individual in getting their work organized. It is used to manage their projects and tasks in such a way that they achieve success.

4. Project management tools

Project management tools are the means that help project managers teams or an individual in getting their work organized and project implemented. "It is used to manage the projects and tasks in such a way that they achieve success. Project management tools are designed to make all aspects of managing projects easier and more efficient, allowing teams to collaborate on a single platform and share files across multiple devices. They can also provide detailed reporting features so that everyone involved in the project has access to an up-to-date status report on progress made so far. A project management tool is now very often a software application that helps project managers and teams plan, organize, coordinate, monitor, and manage the large number of activities necessary to complete a project. It can be used to create team collaboration on tasks, assign resources to specific tasks or sections of the project, set due dates for each task/section, track progress throughout the duration of the project, and more." [5]

The most common project management tools are: network diagrams, critical path method (CPM), Gantt charts, project evaluation and review technique (PERT), work breakdown structure (WBS), logical framework methodology (LFM).

4.1. Logical framework matrix (LFM)

The logical framework approach (LFA), also known as the logical framework methodology (LFM), logical framework matrix or just Logframe, is a systematic and analytical planning process used in the design, planning, execution, and evaluation of projects. This methodology was developed in 1969 by USAID (United States Agency for International Development) in response to analysis of the results of previous projects. By this analysis, it was concluded that there were deficiencies and that it was necessary to create a tool to improve the results of future projects. Subsequently, many organizations and institutions, such as the Inter-American Development Bank (IDB), the German development cooperation agency (GTZ), and many other, mostly governmental institutions, generated variations of this methodology. The most common use of logical framework is in strategic development projects by the state or government level, but also by the private organizations and educational institutions, whenever the results-based planning process is required.

The logical framework matrix as a tool helps to conceptualize, plan, execute and control a project with an approach based on objectives, communication among stakeholders and orientation towards beneficiaries [6]. Here are some definitions of the logical framework approach by different organizations [6]:

- Management tool that facilitates the planning, implementation, and evaluation of a project. Norwegian Agency for Development Cooperation (NORAD), 1993.
- A system of procedures and instruments for objective-oriented project planning. German Agency for Development Cooperation. (GTZ), 1987.
- Analytical tool for objective-oriented project planning and management. It is a method with different steps from identification to formulation and its final result should be the elaboration of a project planning matrix. Spanish Agency for International Development Cooperation (AECID), 1999.

Considering the above definitions, the logical framework matrix is composed of a series of steps such as problem analysis, analytical structure, project narrative, etc. As we follow the steps, we summaries the project. complete the logical framework matrix. "It sets out what the project is intended to do and how it is intended to be done, along with the assumptions it faces and how it will be monitored and evaluated." [6] This is vital when, for example, the project is presented to a potential investor.

4.2. LFM of EU projects

The European Union has a wide structure of funds throughout projects are financed in different areas. However, if the project is financed by these funds, it should be written and implemented according to certain EU rules and regulations. Especially, it is necessary that the idea of project correspondent to

specific program goal(s) from which funding is expected. The idea and project itself need to be well designated and elaborated according to the EU rules. Rigor in project evaluation depends mostly on the amount of donor funds. The conditions for obtaining EU funds are much more rigorous compared to the funds and support granted by domestic institutions. The project requires a detailed explanation of what it wants to achieve, for whom it is being implemented, what results it will achieve, and how these results will be measured later. The European Union prefers certain methods and techniques that include the concept of the project cycle through planning and defining the project according to the principles of the logical matrix, and a coherent structure for key documents and procedures. Logical matrix is a series of related concepts that operationally describe the most important aspects of the project [7].

LOGICAL FRAMEWORK FOR THE ACTION				
	Intervention Logic	**Objectively Verifiable Indicators of Achievement**	**Sources and Means of Verification**	**Assumptions**
Overall Objective	What is the overall broader objectives to which the action will contribute?	What are the key indicators related to the overall objective?	What are the sources of information for these indicators?	Which external factors and conditions are necessary for the action to contribute to the overall objective?
Specific Objectives	What specific objectives are the actions intended to achieve to continue to the overall objective?	Which indicators clearly show that the objectives of the actions have been achieved?	What are the sources of information that exist or can be collected? What are the methods required to get this information?	Which factors and conditions outside the Beneficiaries' responsibility (external conditions) are necessary to achieve the objectives? Which risks should be taken? into consideration?
Expected Results	What are the outputs envisioned to achieve the specific objectives? List the expected results.	What are the indicators to measure whether / to what extent the action achieves the expected results?	What are the sources of information for these indicators?	What external conditions must be met to obtain the expected results on schedule?
Activities	What are the key activities to be carried out in order to produce the expected results? Group activities by result and in the correct sequence.	**Means:** What are the means required to implement these activities (e.g., personnel, equipment, training, studies, supplies, operational facilities, etc.)	What are the sources of information for action progress? **Costs:** What are the action costs? How are they classified? Breakdown the budget for the action.	What pre-conditions are required before the action starts? What conditions outside the Beneficiaries' direct control have to be met for the implementation of the planned? activities?

Figure 3. The logical framework matrix (LFM).

Figure 3 [8] shows logical framework matrix usually used in EU funded projects. This matrix contains clear content and summary of project activities. It serves to check whether the project is well planned and facilitates monitoring and evaluation of the project. The logical framework matrix

systematically reflects the vertical logic of the project: from the overall objective to which the project should contribute and the specific objectives of the project, to the expected results and activities to achieve these results [7].

The matrix, in addition to connecting the goals and purpose of the project with the expected benefits and results, also lists the expected indicators of success and ways of checking them. Indicators and assumptions form an integral part of the horizontal logic of the project. Additionally, costs, i.e., the necessary material and financial resources are listed in a separate field of the matrix.

5. Conclusions

Project management, as a special discipline, plays significant role in the modern economy and businesses. More and more different types of organizations realize their activities within the framework of projects and thus contribute to the continuous development of the business process, which ultimately contributes to the economic growth and development of the entire area. However, each project is a separate for itself, and therefore project management is proactive and dynamic. A project is any occasional and temporary activity that is carried out in an organization in order to achieve a specific goal. Each project, depending on the set goals, available resources, and timeframe, requires different tools, methods and management techniques. The 7-S framework, the project life cycle, and different types of project management tools, such as the logical framework matrix, which are presented in this paper, also play a significant role in project management and successful implementation. All the mentioned methods and tools as a help in project management actually divide the project into phases and determine the sequence of activities, which greatly facilitates adaptability to changes and modern trends as a prerequisite for modern business, development and progress.

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Shaping the digital transformation of the European Union: Actions of the Union institutions and analysis of the European Declaration on Digital Rights and Principles

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Abstract. Digital transformation, as a complex process that affects every aspect of people's lives, brings with it a number of advantages, but at the same time it also includes numerous challenges, both at the European Union and at the global level. Although it entails a process that offers numerous opportunities for greater personal well-being, sustainability and growth, it also increases the risks that require a response from the European Union institutions. In January 2022, the Commission proposed the European declaration on digital rights and principles for the digital decade, which was signed at the highest political level on 15 December 2022 by the Council, the European Parliament, and the Commission. The signing of the Declaration reflects the common political commitment of the European Union and its member states to the promotion and implementation of important principles in all areas of digital life. The Declaration presents the European Union's commitment to a protected, secure and sustainable digital transformation centered on people, in accordance with the Union's fundamental rights and values. The main goals of this research are reflected in the analysis of the actions of the institutions of the European Union in relation to its digital transformation, as well as the assessment of the relevance of the Declaration when it comes to the protection of human rights and democratic values in the digital age. The paper will emphasize the importance of the European Declaration on Digital Rights and Principles at the global level, considering that the Declaration reflects the intention of the European Union to provide a global model for the protection of rights and freedoms in the digital age. The results of the research will show that the Declaration, as a reference document for the future action of the Union in relation to its digital transformation, strengthens the primary role of the Charter of Fundamental Rights of the European Union in the digital age, and serves as a global reference for many new legal, social and ethical issues that digital transformation entails.

1. Introduction

As enshrined in Article 2 of the Treaty on European Union (EU), the Union is founded on the values of respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities. Various studies show that EU citizens are increasingly using digital tools and the internet not just to work, study, socialise and interact with administrations and companies, but also to access different services such as healt and culture. We are aware that access to the internet and the use of digital tools is no longer a novelty, but a necessity. The crisis caused by the COVID-19 virus accelerated this trend, so creating a strong and shared vision for

digital economy and society has become more important than ever after the experiences during the pandemic.

The end of year 2022 was marked by a significant step for the digital transformation of Europe: the President of the European Commission Ursula von der Leyen signed the European Declaration on Digital Rights and Principles, together with the President of the European Parliament Roberta Metsola, and Czech Prime Minister Petr Fiala for the rotating Council presidency, jointly signed, on 15 December 2022, the European Declaration on Digital Rights and Principles for the Digital Decade, as proposed by the Commission in January 2022 and in support of the Digital Compass 2030 objectives. The goal was to ensure that the European Union reaches its objectives for a digital transformation in line with its values and with the Commission's communication ''Digital compass 2030: a European way forwars for the digital decade'' from 9 March 2021.

In particular, the Declaration presents the EU's commitment to a secure, safe and sustainable digital transformation that put people at the centre, in line with the core values and fundamental rights of the European Union. It does this by supporting solidarity and integration through connectivity, digital eduaction, training and skills, fair and just working conditions, as well as access to online digital public services. It is justifed to consider that the Declaration serves as a reference for those responsible for formulating public policies to define a sustainable approach that protects rights and democratic values in the digital age. The Declaration also reinforces the paramount role of the European Charter of fundamental Rights in the digital age. In summary, the Declaration shows citizens that European values, as well as the rights and freedoms contained in the legal framework of the European Union, must be respected online in the same way as they are respected offline.

2. Establishing and endorsing a European Declaration on Digital Rights and Principles for the digital decade

The breath-taking tehnological developments of the 2000s have changed society fundamentally. Much as earlier industrial revolutions redrew economic and political arrangaments, the ongoing information technology (IT) and digital revolutions have far-reaching repercussions for the structure of society. To be sure, the European Union and its member states have much to gain from new technology. Innovation and continued investment may enable the EU to maintain and perhaps even to increase its global competitiveness. At the same time, a variety of voices warn of the problems that follow in the wake of the rapid technological shift [1].

The EU has always played a leading role when it comes to the promotion of fundamental rights at the global level. The Union maintains this role when it comes to the promotion of digital rights and principles based on the human-centred and value-based approach.

In the process of digital transformation different groups of intractably interrelated drivers shape the future of European politics, society and economy [2]. Digitalization has profoundly changed the existing order of the public sphere in Europe [3]. Digital transformation is the process of strategy development to redesign or develop new digital solutions [4].

The locution ''Digital transformation'' indicates a set of technological, cultural, organizational, social, creative and managerial changes associated with digital technology applications in all aspects of human society [5]. The digital transformation of economy and society is based on rapid and often disruptive innovations more and more individuals, businesses, and objects having a global rather than national dimension. Indeed, digital transformation involves all sectors and all countries [6]. Digital society and digital technologies bring with them new ways to learn, entertain, work, explore, and fulfil ambitions. They also bring new freedoms and rights, and give EU citizens the opportunity to reach out beyond physical communities, geographical locations, and social positions. However, there are still many challenges associated with the digital transformation. The digital world should be based on European values - where no one is left behind, everyone enjoys freedom, protection and fairness. Europe's Digital Decade is where everyone has the skills to use everyday technology. The

Digital Decade is a comprehensive framework that will guide all actions related to digital. The aim of the Digital Decade is to ensure all aspects of technology and innovation work for people [7].

Digital technologies are transforming every aspect of our lives, offering unprecedented opportunities. Working, learning, socialising, entertaining, shopping, accessing public administration, healthcare or culture increasingly happen via digital means. The COVID-19 pandemic has radically changed the role and perception of digital in our societies and economies, and has accelerated its pace [8].

This European way for the digital society is also based on ensuring full respect of EU fundamental rights: a) Freedom of expression, including access to diverse, trustworthy and transparent information; b) Freedom to set up and conduct a business online; c) Protection of personal data and privacy, and right to be forgotten; d) Protection of the intellectual creation of individuals in the online space [9].

The European way to a digitalised economy and society is about solidarity, prosperity, and sustainability, anchored in empowerment of its citizens and businesses, ensuring the security and resilience of its digital ecosystem and supply chains. One of the key lessons of the pandemic is that digitalisation can bring people together independently of where they are physically located. Digital infrastructure and rapid connectivity bring people new opportunities. Digitalisation can become a decisive enabler of rights and freedoms, allowing people to reach out beyond specific territories, social positions or community groups, and opening new possibilities to learn, have fun, work, explore and fulfil one's ambitions. This will enable a society where geographical distance matters less, because people can work, learn, interact with public administrations, manage their finance and payments, make use of health care systems, automated transport systems, participate to democratic life, be entertained or meet and discuss with people anywhere in the EU, including in rural and remote areas [10].

Emerging technological breakthroughs in fields such as artificial intelligence, data analytics, robotics, the Internet of Things and their integration into business models and everyday services and products have helped to transform the way the economy and society are organised. The increased pace of the digital transformation has generated major innovations, offering new tools to address global societal challenges and to improve the efficiency of private and public services. At the same time, it has facilitated access to education and training and to information resources and opened new spaces of public discourse. The widespread adoption of digital technologies has enhanced our freedom, connecting even the most remote locations, creating new opportunities for citizens, for workers and consumers; for businesses to be created and prosper; for communities to thrive; for the inclusion of disadvantaged groups; and for our society to advance as a whole [8].

The digital transformation does not justify exceptions to the rights and freedoms that the Union citizens enjoy under EU law. Rather, it should aim at the reinforcement of those rights and freedoms. The Union is committed to empowering all Europeans to benefit fully from the opportunities brought by the digital transformation, regardless of their age, gender, abilities, condition, or geographical location and has taken both corrective and preventive actions by adopting the necessary regulations and policy measures in all of these areas in recent years. However, as technological solutions affecting our lives become increasingly intertwined, pervasive and complex, it becomes increasingly urgent to step up efforts for achieving an open, fair and equal access to digital tools, services, infrastructures and skills which can ultimately strengthen our democracies [11].

With the European Declaration on Digital Rights and Principles for the Digital Decade, the Commission sought to establish a reference framework for people and guide for businesses and policy makers, all with a single aim: to place people at the center of digital transformation.

The Declaration was established on previous initiatives from Member States and from the European Parliament, and benefits from numerous contributions gathered during the public consultation. When it comes to public consultation on a set of European digital principles, between 12 May and 6 September 2021, the Commission carried out a public consultation to gather views on the formulation of European digital principles to promote and uphold EU values in the digital space. The public consultation was promoted during the event "Leading the Digital Decade" on 1-2 June, on the digital platform of the Conference on the future of Europe as well as on social media accounts [12]. Leading the digital decade, was a two-day online event focused on the digital transformation of Europe towards 2030, and aimed to

answer important questions such as *what shouls the future of digital in Europe be*, *what should our 2030 goals be when it comes to digital transformation* and *how can we make sure we meet our goals?* This event was jointly organized by the European Commission and the Portuguese Presidency of the Council of the European Union.

The European Commission launched a public consultation on a set of European Digital Principles on the *Have your say* online portal to gather views on the formulation of European digital principles. The consultation was made available in all 24 official EU languages, ensuring that the public consultation was accessible to as many stakeholders as possible, especially citizens.

The consultation activities had primarily the following objectives: (1) bring the initiative to the attention of stakeholders and measure support for the establishment of a clear set of digital rights and principles; (2) collect concrete feedback, opinions and views on the formulation of specific digital rights and principles [13].

The main objective of the consultation was to collect the views of all interested stakeholders including Member States, regional and local authorities, nongovernmental and civil society organisations, business associations and companies, other interested parties, and, of course, citizens. This marked the opening of a broad consultation exercise, including participatory workshops and targeted interviews, a Eurobarometer survey to gather views across Member States, and different age groups, with a particular focus on children and young people and different social backgrounds. Overall, the consultations showed broad support for a European Declaration on Digital Rights and Principles as well as on the first set of principles outlined in the open public consultation, highlighting the importance of some of them over the others and with some respondents stressing the need for additional principles. The responses to the different consultation activities have guided the design of the Declaration [14].

The Commission's communication ''Digital compass 2030: a European way forward for the digital decade'' of 9 March 2021 presented the vision for a digitally transformed Europe by 2030 in line with European values. The EU's ambition is to be digitally sovereign in an open and interconnected world embracing empowered citizens and innovative businesses in a human-centred, inclusive, prosperous, and sustainable digital society.

The end of year 2022 was marked by a significant step for the digital transformation of Europe: the President of the European Commission Ursula von der Leyen signed the European Declaration on Digital Rights and Principles, together with the President of the European Parliament Roberta Metsola, and Czech Prime Minister Petr Fiala for the rotating Council presidency, jointly signed, on 15 December 2022, the European Declaration on Digital Rights and Principles for the Digital Decade, as proposed by the Commission in January 2022 and in support of the Digital Compass 2030 objectives. The Commission is monitoring progress on the implementation of the objectives of the Declaration and provides recommendations through an annual ''State of the Digital Decade report''.

2.1. The nature of the Declaration on Digital Rights and Principles

The set of digital principles that should shape Europe's digital society is proposed in the form of a joint solemn declaration of the European Parliament, the Council and the Commission. The Declaration is non-binding thus not affecting legal obligations nor creating new rights for citizens.

The Declaration notably builds on primary EU law, in particular the Treaty on the European Union (TEU), the Treaty on the Functioning of the European Union (TFEU), the EU Charter of Fundamental Rights and the case-law of the Court of Justice of the European Union, as well as on secondary EU law. These principles do not affect the legal rights that already protect people online within the European Union, and for which effective remedies must exist across the Union. Nor do they affect lawful limits on the exercise of such legal rights, in order to reconcile them with the exercise of other rights, or necessary and proportionate restrictions in the public interest. When implemented through policy initiatives, such principles will be applied together with existing rights and principles and for the overall public interest [15].

Although the Declaration does not have binding legal force, we believe that it presupposes something more than mere political intention. We can see the Declaration as a document that expresses the values

that the EU wants to protect in the digital age, but we must certainly take into account that the Declaration is part of a broader constitutional picture. The Declaration is actually a certain type of manifestation of the consolidation of digital constitutionalism, which emphasizes that the digital future of the EU is supported by digital program presided over by European constitutional values.

The Digital Decade Policy Programme is specified in Decision (EU) 2022/2481 of December 14, 2022, and it establishes the strategic program of the EU Digital Decade for 2030 [16]. It is important to underline that the Digital Decade Policy Programme, adopted just few days after the Declaration on Digital Rights and Principles, is a European decision and thus it has direct and binding effect on Member States unlike other documents. It complements and concretizes the objectives of the 2030 Digital Compass, and complements some of the European Pillar of Social Rights objectives, as well as it refers to further initiatives, including the Declaration on Digital Rights and Principles

Although the Declaration is not binding for the EU States or individuals, it may bind institutions entering into the agreement.

3. Connect and significance of the Declaration on Digital Rights and Principles

There are many reason to be optimistic about the digital transformation potential of Europe. Europe has unique resources in its diversity of skills and ideas, held together by common values and mechanisms for cooperation towards a common goal. Digital innovation is a European idea at heart and Europeans are credited with fundamental discoveries like that of electromagnetism, and inventions like the World Wide Web. Standing on the shoulders of previous generations of Europeans, decision makers can accelerate now to capture the value of digital innovation in line with European values [17].

Deploying digital infrastructures, skills and capacities and digitising businesses and public services alone is not sufficient to define the EU's approach to its digital future; it is also necessary to enable all Europeans to make full use of digital opportunities and technologies. In the digital space, we need to make sure that the same rights that apply offline can be fully exercised online. To be fully empowered, people should first have access to affordable, secure and high quality connectivity, be able to learn basic digital skills –which should become a right for all- and be equipped with other means which together allow them to fully participate in economic and societal activities of today and the future. They also need to have easy access to digital public services, on the basis of a universal digital identity, as well as access to digital health services. People should benefit from non-discriminatory access to online services and as well from the realisation of principles, such as secure and trusted digital spaces, work-life balance in a remote working environment, protection of minors, and ethical algorithmic decision-making. In addition, the digital technologies and services people use must be compliant with the applicable legal framework and respect the rights and values intrinsic to the "European way". Furthermore, the human-centred, secure and open digital environment should comply with the law, but also further enable people to enforce their rights, such as the rights to privacy and data protection, freedom of expression, the rights of the child and consumer rights [18]. From the content of the Declaration, it follows that the core principles are formulated in 6 chapters: a) Chapter I: Putting people at the centre of the digital transformation; b) Chapter II: Solidarity and inclusion; c) Chapter III: Freedom of choice; d) Chapter IV: Participation in the digital public space; e) Chapter V: Safety, security and empowerment; and f) Chapter VI: Sustainability [19].

The European digital rights and principles contained in the Declaration supplement existing rights, such as data protection, ePrivacy, the Charter of Fundamental Rights, and are built on the experience of the European Pillar of Social Rights. They also provide guidance for the EU and Member States regarding their adaptation to the digital transformation. The digital principles are rooted in primary EU law, notably the Treaty on European Union (TEU), the Treaty on the Functioning of the European Union (TFEU), the Charter of Fundamental Rights and the case-law of the Court of Justice of the European Union, as well as in secondary legislation. The Declaration relies on a mixed or hybrid normative approach. Actually it enriches both righs and principles, and it recalls ''the most relevant'' rights already

provided by the EU Charter of Fundamental Rights, clarifying which existing obligations apply to the digital environment [20].

Observing from a constitutional perspective, we are of the opinion that the Declaration brings additional value to the state of protection of online users' interests in the European Union. If we look at it's content - some of the existing principles in EU law are expanded in scope, while others are completely new formulations in the EU regulatory landscape - the Declaration goes a step beyond the traditional approach by elaborating some new principles with a unique digital rationale, and adopts an innovative, progressive and transformative approach.

4. Concluding remarks

The results of the research showed that Europe has a unique aim: to empower businesses and people in human-centred, sustainable and more prosperous digital future. We can say that the digitalisation endows people with new sources of prosperity, enabling entrepreneurus to innovate, establish and develop their businesses wherever they live, opening markets and investments across Europe and the world, and creating new jobs and business opportunities at a time when an increasing number of Europeans feel threatened in their economic environment. The EU works almost every day in order to improve its human-centered digital agenda on global stage and to promote alignment to convergence with EU norms and standards, striving to deliver global solutions. On the basis of the Commission's proposal, a significant set of digital principles and rights is included in the inter-institutional solemn Declaration between the European Commission, the European Parliament and the Council, building on and complementing the experience of the European Pillar of Social Rights - the European Declaration on Digital Rights and Principles for the Digital Decade.

The signing of the Declaration reflects the common political commitment of the European Union and its member states to the promotion and implementation of important principles in all areas of digital life. The Declaration presents the European Union's commitment to a protected, secure and sustainable digital transformation centered on people, in accordance with the Union's fundamental rights and values.

Observing from a constitutional perspective, we are of the opinion that the Declaration brings additional value to the state of protection of online users' interests in the European Union. If we look at it's content - some of the existing principles in EU law are expanded in scope, while others are completely new formulations in the EU regulatory landscape - the Declaration goes a step beyond the traditional approach by elaborating some new principles with a unique digital rationale, and adopts an innovative, progressive and transformative approach.

The results of the research showed us that the Declaration, as a reference document for the future action of the Union in relation to its digital transformation, strengthens the primary role of the Charter of Fundamental Rights of the European Union in the digital age, and serves as a global reference for many new legal, social and ethical issues that digital transformation entails. The Declaration brings a number of advantages when it comes to the EU and its external actions, because the Declaration guides the EU in its international relations, helping to shape the global digital transformation that puts people and human rights at its center. In the Preamble of Declaration is stated that ‘’the EU should promote the Declaration in its relations with other international organisations and third countries, including by reflecting these rights and principles in its trade relations, with the ambition that the principles guide international partners towards a digital transformation that puts people and their universal human rights at the centre throughout the world’’, and ‘’the Declaration should notably serve as a reference for activities in the context of international organisations, such as the realisation of the Agenda 2030 for Sustainable Development, as well as the multistakeholder approach to Internet governance’’. As stated by the Portuguese Secretary of State for the Digital Transition, André de Aragão Azevedo, the Declaration provides “the European economic model” and furthers “trust-based partnerships with other countries and continents that share European principles and values”.

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Coagulation activity of natural coagulants for removal of turbidity in wastewater treatment

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Abstract. Natural waterways are contaminated due to industrialization, urbanization and population growth. Contaminated waterways cause numerous health and environmental hazards. Coagulation is one of the efficient primary chemical treatment methods that could be used to treat such contaminants. Coagulation and flocculation by adding chemicals are the methods that are usually used for removal of water turbidity. Natural coagulants have gained popularity in the water and wastewater treatment industry due to their advantage over chemical coagulants. Efficiency of natural coagulants extracted from common bean (*Phaseolus vulgaris*) seed in water turbidity removal was experimentally evaluated. Natural coagulants were extracted from crushed beans using 0.5 M NaCl. Two types of wastewater were used in experiments: municipal wastewater and technological wastewater (wastewater from beer production). Experiments were conducted with different doses of coagulant at different pH values. Prepared fraction has shown differences in behavior regarding pH values and dosages at which prepared fraction expressed its highest efficiency in turbidity removal. Results showed that the highest removal efficiency was achieved in municipal wastewater at pH 11.5 with applied dose of coagulant of 5 mL/L, and it was 96.5%. The best coagulation activity in wastewater from beer production was achieved at pH 5 with dose of 30 mL/L, and it was 87.31%. The initial value of turbidity in municipal wastewater was 257 NTU, and in wastewater from beer production 93.86 NTU.

1. Introduction

In order to sustain the water requirements, various processes and technologies are being researched to improve the quality of water [1]. These technologies fall into three main categories: physical, chemical, and biological treatment methods.

Coagulation and flocculation are commonly used methods for water turbidity removal. Coagulation is the simple method in water and wastewater's primary treatment for removing suspended particulate matter and colloids in wastewater [2]. Successful coagulation can be attained by using either chemical-based (inorganic and synthetic organic) coagulants or natural coagulants [3].The most commonly used coagulants are aluminum and iron salts [4]. Aluminum salts are cheap, but there are some indications that residues from these salts can cause Alzheimer's disease [5]. The application of synthetic polymers as coagulants is undesirable, because the residual monomers have neurotoxic and strong carcinogenic properties [6].

Intensive investigations of natural coagulants have been conducted in the last years in order to replace chemical coagulants in water and wastewater treatment. Their advantages over chemical coagulants are biodegradability, low toxicity, and low residual sludge production [6]. Natural coagulants are produced or extracted from different sources such as microorganisms, animals, or

plants (non-plant-based and plant-based) [7]. Several effective coagulants which have plant origin are being identified. Some of the common ones include *Hibiscus sabdariffa* (Roselle seeds) [8], *Dolichos lablab* (Hyacinth bean) [9], *Moringa oliefera* [10], Nirmali seeds [11], watermelon seeds [12] and cactus species [13]. The successful coagulation of natural coagulants [14] stands on these three pillars: characteristics of coagulant used, characteristics of water to be treated, characteristics of mixing process [14,15]. Fast mixing increases the interactions between coagulants and suspended particles and forms micro flocs. Slow mixing leads to the aggregation of micro flocs into large flocs [7].

The aim of this study was to investigate the efficiency of use of natural coagulants extracted from common bean (*Phaseolus vulgaris*) for turbidity removal in two types of wastewater: municipal and technological wastewater. Coagulation efficiencies of prepared fractions were measured at different pH values and dosages.

2. Materials and methods

Natural coagulants were extracted from common bean seeds. Common bean seeds were grounden using laboratory mill and passed through a sieve with pore size of 0.4 mm. An amount of a 10 g/L of the smaller fraction was suspended in 0.5 mol/L NaCl. This suspension was stirred 10 minutes on a magnetic stirrer in order to extract active coagulant. After that, the suspension was filtered through filter paper. Filtrate was used as natural coagulant.

Two types of wastewater were used in experiments: municipal wastewater and technological wastewater (wastewater from beer production). All parameters were determined according to Standard Methods [16].

The coagulation activity was assessed by jar test using municipal wastewater and technological wastewater (wastewater from beer production). Natural coagulant was added to 500 mL for both types of wastewater at different pH values. Coagulation tests were conducted at pH 5, 6.7 and 9 for technological wastewater and pH 5, 5.8 and 11.5 for municipal wastewater. pH was adjusted using 1 mol/L HCl or NaOH before performing coagulation test. Test was carried out by adding different amounts (5 ml and 30 ml) of extract to 500 ml of wastewaters. The content was stirred at 200 rpm for 1 minute and then reduced to 140 rpm and was kept for 90 min. After that the system was left to sediment for 1 h. The same coagulation test was conducted with no coagulant (blank).

After sedimentation for 1 h, residual turbidity was determined in upper clarified liquid, using turbidimeter and coagulation activity was calculated as:

$$\text{Coagulation activity (\%)} = ((\text{RTB} - \text{RTS}) / \text{RTB}) \bullet 100 \quad (1)$$

RTB - residual turbidity of blank
RTS - residual turbidity of sample.

Turbidity was expressed in nephelometric turbidity units (NTU).

3. Results and discussion

The initial parameters for the technological wastewater indicate moderate turbidity, slightly acidic pH, moderate conductivity, normal temperature, the presence of ammonia and increased COD level, as shown in Table 1. Proper treatment and management of these parameters are important to ensure the effective treatment and disposal of technological wastewater, as well as to minimize its environmental impact.

Table 1. Initial parameters of technological wastewater.

Parameter	Measuring unit	Value
Turbidity	NTU	93.86
pH value	-	6.7
Conductivity	µS	914
Temperature	°C	20
Ammonia	mg/L	10.4
Chemical Oxygen Demand	mg/L	280

The initial parameters for the municipal water indicate high turbidity, highly alkaline pH, significant conductivity, normal temperature, the presence of ammonia, and slightly increased COD level (Table 2). These parameters highlight the importance of proper treatment processes to ensure the quality and suitability of municipal water for various applications.

Table 2. Initial parameters for municipal wastewater.

Parameter	Measuring unit	Value
Turbidity	NTU	257
pH value	-	11.5
Conductivity	µS	3.29
Temperature	°C	20
Ammonia	mg/L	7.11
Chemical Oxygen Demand	mg/L	180

In summary, the initial parameters for municipal water show higher turbidity, alkaline pH, higher conductivity, lower ammonia concentration, and lower COD compared to the parameters of the technological wastewater. These differences reflect the specific characteristics and requirements of each water source, highlighting the need for tailored treatment processes to meet the desired quality standards for each application.

This research highlights the pH-dependent coagulant activity for municipal and technological wastewater treatment using a coagulant extracted from the common bean. Two different coagulant doses, 5ml and 30ml, were tested at varying pH levels.

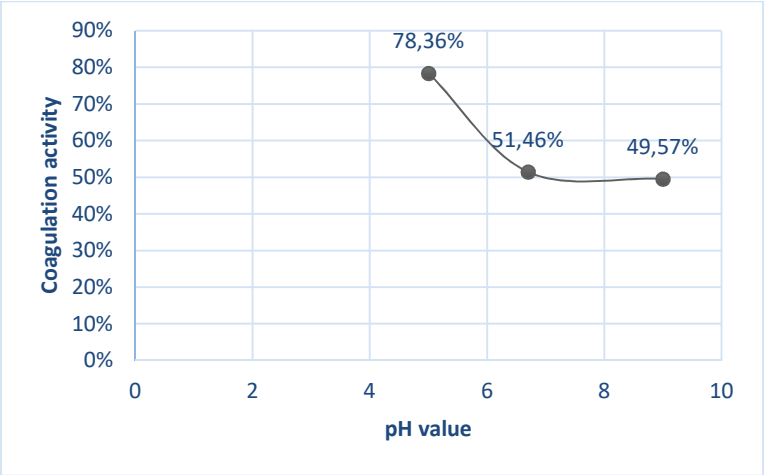

Figure 1. The coagulation activity of the natural coagulant at a dose of 5 ml for various pH values in technological wastewater.

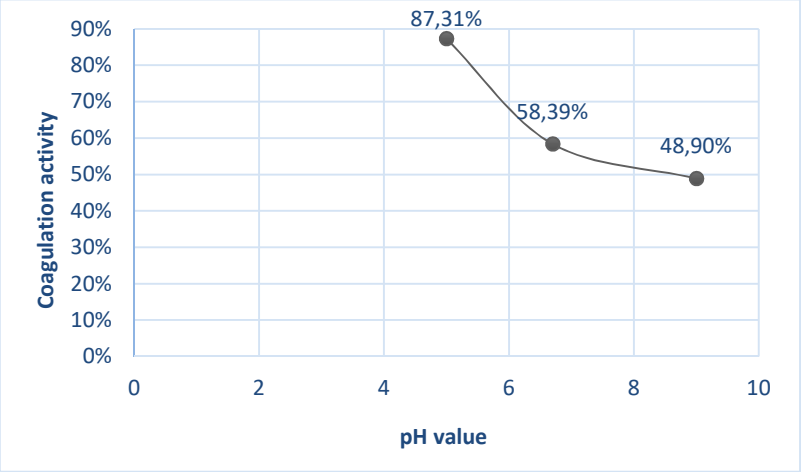

Figure 2. The coagulation activity of the natural coagulant at a dose of 30 ml for various pH values in technological wastewater.

For technological wastewater treatment, at pH 9, the coagulant activity for the 5ml coagulant volume was measured to be 49.7%, while for the 30ml coagulant volume, it slightly decreased to 48.9%. Contrary to our results, Kukić et al. (2018) showed that the best results (98.8%) in stillage wastewater were at a pH 9 with a coagulant dose of 5ml/l [17]. At pH 6.7, the coagulant activity increased to 51.46% for the 5ml coagulant volume and significantly improved to 58.39% for the 30ml coagulant volume. The highest coagulant activity was observed at pH 5, where the 5ml coagulant volume exhibited an activity of 78.36%, while the 30ml coagulant volume achieved a significantly higher activity of 87.3% (Graph 1 and 2). Consistent with our findings, Kukić et al. (2018) demonstrated a significant coagulation activity of 90.1% when using a dose of 0.4 ml/L at a pH of 5.5 in model water [17]. In addition to the influence of pH on coagulation activity, it is important to take into account the coagulant dosage as another significant factor. In technological wastewater, as the coagulant dose increased, there was a decrease in coagulation activity at a higher pH value, in agreement with the research of E. Prihatinningtyas (2019) [18].

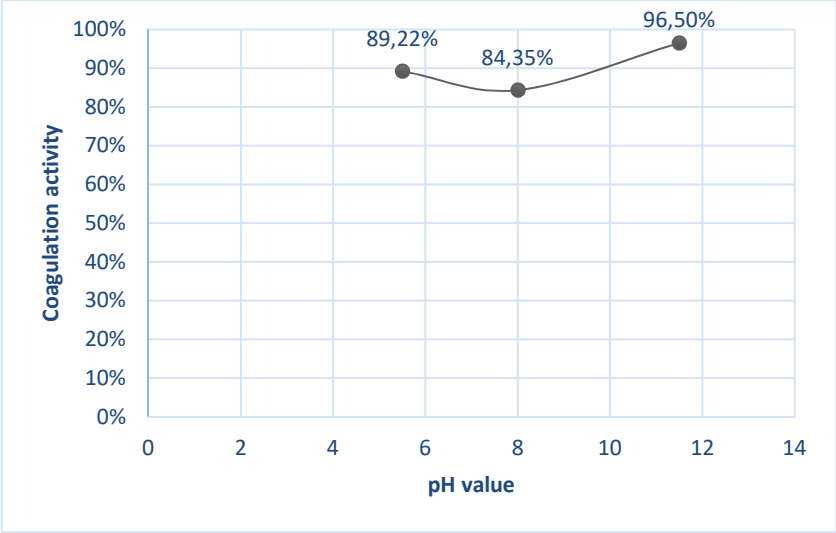

Figure 3. The coagulation activity of the natural coagulant at a dose of 5 ml for various pH values in municipal wastewater.

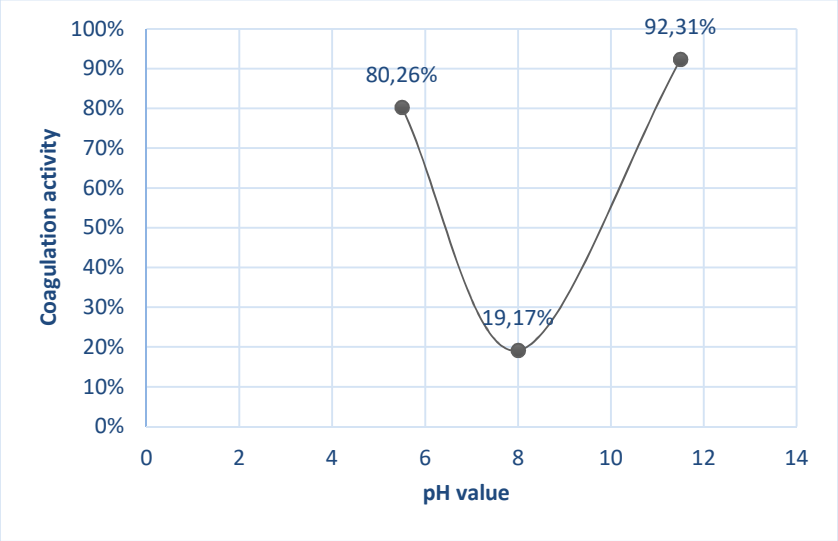

Figure 4. The coagulation activity of the natural coagulant at a dose of 30 ml for various pH values in municipal wastewater.

For municipal wastewater treatment, at pH 11.5, the coagulant activity for the 5ml coagulant volume was measured to be 96.5%, while for the 30ml coagulant volume, it decreased to 92.31%. At pH 8, the coagulant activity decreased further to 84.35% for the 5ml coagulant volume and significantly dropped to 19.17% for the 30ml coagulant volume. At pH 5,5, the coagulant activity increased to 89.22% for the 5ml coagulant volume and remained relatively stable at 80.26% for the 30ml coagulant volume (Graph 3 and 4). Turbidity removal demonstrated greater efficiency under alkaline conditions, specifically at a pH of 11.5. These findings align with previous studies that have shown higher pH values to be more favorable for the optimal performance of natural coagulants derived from sources such as Moringa oleifera [19], cactus [13], chestnut, and acorn [20].

Furthermore, the coagulation activity demonstrated comparable performance in both alkaline and acidic conditions, except for a slight reduction at pH 8 when 5ml/L of the coagulant was introduced. These findings are consistent with previous research investigating the use of Moringa oleifera for the removal of Congo red dye from wastewater [21].

In the study conducted by Šćiban et al. (2010), the findings exhibited variations, yet highlighted the highest coagulation activity (approximately 45%) within the range of applied coagulant doses from 3.5 mg/L to 4.5 mg when utilizing synthetic wastewater at pH 9 [6]. Incosistent with E. Prihatinningtyas (2019) work, the coagulation activity in municipal water showed an opposite trend, with an increase observed as the coagulant dose increased [18].

4. Conclusions

The results indicate that both coagulant concentration and pH significantly influence coagulant activity in both types of wastewater. Higher coagulant volumes generally lead to increased coagulation efficiency, while optimal pH conditions enhance coagulant activity. For municipal wastewater, the highest coagulant activity was observed at pH 11.5, while for wastewater from beer production, pH 5 yielded the highest activity, emphasizing the importance of pH optimization in wastewater treatment.

When comparing the two wastewater types, it is evident that municipal wastewater generally requires higher coagulant volumes and exhibits higher coagulant activity compared to wastewater from beer production. This discrepancy can be attributed to the different compositions and characteristics of the wastewater. It is essential to optimize the coagulation process based on the specific wastewater type to achieve efficient treatment.

These results provide valuable insights for optimizing the treatment of municipal and wastewater from beer production by considering coagulant concentration and pH conditions. Understanding the

specific requirements of each wastewater type is crucial for achieving efficient and sustainable treatment processes. Further research can explore the underlying mechanisms responsible for the observed effects, evaluate the impact of other process parameters, and assess the feasibility of scaling up the coagulation process for practical wastewater treatment applications.

Implementing these research findings can contribute to the development of improved wastewater treatment strategies, promoting environmental protection and public health.

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How to do business successfully

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Abstract. Business, i.e. successful company management, has always been a challenge and studied as a specific science from the point of view of different skills, conditions, knowledge and decision-making. Companies are exposed to complex global influences, but also to systematic, scientific and general regulations and the need to resist them through their application. It is indisputably and absolutely confirmed that every company must experience and enter a crisis. It is the result of more permanent or periodically unresolved open issues, as problems and difficulties in business. If, in addition, care is not taken to identify risks and opportunities, the influence of both national and international regulations is not considered, the procedural approach to business management, the application of business principles is omitted, then entering into a crisis is inevitable. To these statements, it is obligatory to add omissions from an undetermined and not updated context, whereby we use a number of methods, analysis and similar, in order to direct the organization's operations and encourage the achievement of success. Running business towards success requires continuous monitoring of business indicators, their analysis and determination of necessary measures and projects to eliminate inconsistencies and improve business. We must have the willingness, will and skill to undertake known methods and techniques in improving and solving problems in business processes. Also, it is necessary to measure more, to monitor tendencies throughout the entire cycle of reproduction, to ensure the full engagement of employees. In the end, everything must be expressed by a unique basic indicator of the quality of the business system, that is, the company's operations. Therefore, we must see the management of the company/business as a process with the use of management methods and techniques, planning, monitoring achievements, analyzing the results, undertaking the necessary measures and activities, implementing improvements, while making operational, tactical and strategic decisions.

1. Introduction

Business, that is, measurement and assessment of business performance in the theory of economics as a scientific discipline, is very well, substantively and applicably processed.

A smaller part, it is known in practical application that the problem of business, that is, ensuring success lies in the differences between the needs of practice and the available understanding of scientific methods for successful business. There are several reasons why this is so. Among other things, it is ignorance, lack of practice, habits, and skills to master them, insufficient understanding of the benefits of their application, even certain doubts that their use will improve business, manage changes, accumulate organizational knowledge and finally create assumptions for a systematic approach business, ensuring assumptions for perspective, growth and development.

By discussing this topic, the author wants to present his scientific views, understanding of practice, experiences gained through the application of methods and try to provide answers to the question of how to do business successfully.

In the context of these intentions, a brief commentary on the business operations of business entities in the FBiH will be given, the assumptions for successful business will be systematized, which key indicators should be monitored for successful business, how to measure business success and guide the strategy and achievement of goals, what are the procedures for successful business, and management methods, improvements and problem solving in business.

Companies, and especially most of their managers, want to create and achieve success. It is not possible to achieve this without new/innovative knowledge from economics, management, standards, regulations, constant education and especially respect for global changes, process functioning and the need to monitor and adapt to modern trends and knowledge.

Any other behavior and only the desire to succeed leads the company to failure.

This work is intended to point out the reality or assertion, if we want to succeed then we have to open the work process towards success and lead it in a structured methodical way.

2. Performance evaluation of the business entities

A total of 25,270 companies operated in the Federation of Bosnia and Herzegovina in 2022. 72% (18,302) are micro companies, 22% (5,563) are small, 4.5% (1,126) medium and 1.1% (279) large companies.

Micro companies employ 11.5% of the total number of employees and generate 4.2% of revenue, while small, medium and large companies employ 88.5% of the total number of employees and generate 95.8% of revenue. The profit rate for micro company was 7.4%, and for small, medium and large companies 6.4%, and they are classified as medium profit rates.

Over 40% of micro companies (7,383 companies out of 18,302 of them) have losses and zero business results (970 companies). About 8% of small, medium and large companies report business losses in 2022. The growth of employees was achieved at a rate of 4.6%, and income of 23.7%, primarily due to the increase in prices. Productivity growth obviously did not occur because the growth of employees and income do not correspond (the growth rate of income is more than 5 times higher than the growth rate of employees).

Micro companies generate income per employee of around 78,000 KM, while small, medium and large companies generate around 162,000 KM (2.1 times more). It is quite clear that 40% of micro companies are in losses and difficulties (low productivity), and only 8% of small, medium and large companies. A unique indicator for all companies is that 27.5% of them operate at a loss and 3.8% at zero, which is a total of 31.3% or 7,910 companies.

Practically one-third (1/3) of companies in the Federation of Bosnia and Herzegovina have difficulties, problems, inconsistencies in process factors and similar, and this indicator indicates the presence of more serious deficiencies related to business management and thus achieving success.

In addition to this situation, 60% of employees (about 225,000) have a salary of up to 600 KM/month, and the coverage of the consumer basket is 47%. [1]

3. Assumptions for successful business

Companies strive and aspire to successful business. However, achieving success in anything, including business, requires defining the assumptions for its realization and a clear/unambiguous approach to them and respecting them leading to success.

Achieving success in business is not easy or simple. There are two key reasons for this claim:

- It is necessary to possess the qualities of a successful manager and the ability to lead towards success.
- Understand constant threats to success, such as diverse changes, competitive action, regulatory requirements, market demands and create readiness for responses or adjustments.

The first reason requires creativity, willingness to take risks, understanding, tolerance, systematic approach, ability to manage problems, encourage ideas and improvements, define roles and responsibilities, train co-workers, vision and focus on important issues/problems and priorities.

A manager committed to success builds a competent managerial structure ready for new steps forward, vision, mission, goals must be established, policies by business functions and systemic policies, strategies are adopted, and business is especially planned, achievements are analyzed and measures and projects for improvements are adopted.

It is crucial to define the processes, the context of the organization and analyze the risks. [2] In addition to the managerial/management, main and auxiliary processes, the processes of measurement, analysis and improvement play an important and irreplaceable role for successful business. These last will indicate the need to adopt contingency plans for solving identified problems, improvements and implementing changes. One important assumption or even the most important one for successful business is privatization.

It was mostly carried out without the supervision of institutions, without a prominent and clear interest of the state, and was completely left to personal or group interests. So many companies became unsuccessful and then disappeared. Numerous experts share the opinion and assessment that privatization has created a real miracle in a negative sense. In addition to the fact that the state was damaged for its capital and the companies were left without it, because it ended on personal levels, and not in the modernization of capacities and the financing of production growth.

If we miss, deviate or do not act according to the stated principles, then we do business with ignorance, disorder and irresponsibility, and success in these conditions is not possible.

The second reason is that the preparations of the company for the single market have not been carried out (EU Memoranda '92), the operation and impact on business of extensive and demanding regulations, both international and national (standards, directives, regulations, laws, rules, guidelines...) have not been understood to a sufficient extent as an obligation to apply for the purpose of removing barriers and enabling or successful business. [3]

An implemented quality management system according to ISO 9001 and the application of Directives/Regulations are not a guarantee, but they are key assumptions for success.

The standards and related to them the application of principles of quality and business management, risk management, updating the context of the organization, application of the PDCA cycle in business management, are profound changes and they required new and expanded knowledge and skills of all, especially managerial structures. [4]

Many companies did not adopt strategies, did not even adopt annual or operational plans, set goals, and especially measurable goals, as the basic requirements and needs of successful business management. [5]

Accordingly, reports and analyzes are missing in order to predict improvements and necessary changes based on the data and information obtained.

In the conditions of adapting to the market, which is completely present today, business must be done according to the non-cost principle (selling price - costs = profit) [6], and this is possible only by applying the principles of quality management, risk management, changes, development, and continuous growth, improvement competitiveness and business innovation.

According to the evaluations of business entities, a significant number of managerial structures did not follow these requirements.

The author of this paper also mentions the importance of monitoring, considering and taking measures through the reproduction cycle of quality in material and financial condition. [7] Then, constant control of compliance of process factors (work, means, and objects of work), i.e. their relationships and participation in income or created values.

Prof. dr. Kasim Tadić in his research found that 70% of managers do not know what their tasks are and do not know how to do their job, 70% of workers are not best engaged in their work, etc.

With the situation of non-respect of the above requirements for the purpose of changes and possibly ignoring them, the business will not be successful.

4. Key business indicators

We can manage our business if we have data and information about our business achievements, movements and effects according to defined processes. We obtain this data from the process of measurement, analysis and improvement. From these processes, data and information enter the management processes where they are processed, make the necessary decisions and solutions, act further through the main and auxiliary processes, following the PDCA (plan, do, check, act) cycle.

The key business indicators that should be monitored, analyzed, evaluated and acted upon are as follows: [8]

- realization of purchases, by materials, suppliers, markets, services,
- realization of sales revenue, by products, customers, markets,
- realization of production, by products, product groups, processes,
- capacity utilization, by processes, lines, in total at the company level,
- employees and employment, structure of employees, fluctuation,
- assessment of customer and supplier satisfaction in the partnership relationship,
- monitoring raw materials and materials stocks and maintaining optimal levels,
- monitoring the stock of finished products and maintaining the dynamics of deliveries,
- balance of cash flow, i.e. how the inflow covers business costs,
- monitoring the implementation of the strategy in order to know whether the existing strategy is producing results or whether changes need to be made.

Very important indicators of business success, which should also be monitored, are:

- productivity, because it is necessary to produce or achieve as much value as possible with as little labor cost as possible,
- economy, the goal is to achieve the highest possible income with the lowest possible costs,
- profitability, achieving the highest possible profit with the lowest possible costs (indicator of measuring the efficiency of the use of resources).

The indicated indicators should be monitored continuously, analyzed for shorter business periods (monthly, quarterly), because you don't need to wait for an annual period to improve business and make changes.

All the above indicators point to achieved desired goals, or to deviations, but in any case, an opportunity to take the necessary measures, corrections or to mark a certain phenomenon as positive and encouraging.

5. Quality of the business system

Every business system has certain foundations for its survival and strives to fulfill its goals and purpose of existence. These foundations are in its resources, possibilities and capabilities of production processes, the market, and the effects that production processes and the market achieve.

In order to become and develop, the business system must achieve the necessary level of quality for such purposes, and that is how we talk about the quality of the business system.

The author of this paper, as a unique quality of the business system, creates the following form. [9]

$$N_{kv} = S_{kv} + K_{pi} + K_{iz} + R_{kz}. \quad (1)$$

Where:

- N_{kv} = new/achieved quality
- S_{kv} = present quality
- K_{pi} = quality of proposal/idea/initiative/innovation
- K_{iz} = quality of execution/ realization
- R_{kz} = quality of use/ increase in satisfaction, safety, effects,

A company that changes its condition also changes its quality - it achieves some new quality, which does not exist without changes. If there are no changes, then $N_{kv} = 1+0+0+0 = 1$, that is, the new quality is equal to the current quality (there are no changes and the existing state is maintained).

If the company is active on changes, then $N_{kv} = 1 + 0.5 + 0.5 + 1 = 3$. So a company that does not have changes is three times behind, as can be seen from these patterns in their absolute values.

For a complete assessment of the quality of the business system, the author further modeled the application of the above forms using:

- degrees for evaluation and determination of the quality level of the business system and
- criteria/ perspective of business quality for assessing the quality of the business system.

Using forms, assessment of the level/degree of changes, and criteria related to customers, employees, changes, quality, growth and development and processes, the company can determine a unique assessment of its business system and, based on the assessed criteria, make a whole series of measures and improvements that should be undertaken.

Elaboration of these models requires space, which we cannot provide in this paper. The key and most important thing for the business success of a company is the engagement of staff.

In his practice, the author of this paper observed the engagement of staff and developed a model for evaluating the movement of proposals / ideas and their implementation. In this context, the effectiveness of staff activities is evaluated from the point of view of:

- movement of proposals and implementation from the top (management) down (executors),
- movement of proposals and implementation in one direction only, from the administration to the executors (one-way).

The efficiency and effectiveness of staff in unidirectional activities is lower by 63%. This confirmed the importance of staff involvement, the two-way movement of their activity, that is, teamwork. The success of the business as well as the way out of the crisis depend directly on the employees, their involvement and competence.

Therefore, to achieve business success and maintain it, it is not enough to have the will and knowledge to carry out tasks and jobs. It is necessary to have the skills, expertise and courage to invest in business and in raising the quality of products and processes.

Management must always research, analyze and find the best solutions and systematically manage costs.

According to P B Crosby, a company can evaluate its success or the quality of its business system using the coordinate network of an eternally successful organization. [10]

In doing so, they will use evaluations of their quality, increase in customer satisfaction, attitude towards changes and employee movements.

Based on these parameters, it can qualify its condition as a comatose state, a state requiring intensive care, progressive care, organizational recovery and the degree of health of the organization/company.

Obviously, there are many ways for companies to monitor their situation, assess the quality of business and performance and accordingly create measures, plans, changes, etc., in order to improve their business or get out of the crisis.

6. Procedures for successful business

Successful business requires desire, determination, persistence, and especially the knowledge and skills of managerial structures. Even this will not be enough if we do not carry out certain activities that will enable success and support our will.

It is about several procedures or activities that company managers have to undertake. The most important of them are the following [11]

- the company must make mandatory plans, from operational to long-term ones, including business policies and goals (strategic, tactical, and operational),
- must bring current marketing plans.,
- identify interested parties and establish constructive relations,

- identify risks (organizational, technical, programmatic, financial, strategic, management risks),
- establish and periodically update the context of the organization,
- establish processes and maintain them according to the principles of process functioning,
- to structure and form an adequate organizational structure,
- predict the necessary resources and improve their availability,
- monitor and analyze the narrow and wider environment,

Furthermore, the company must focus maximum attention on customers, employees, costs, suppliers and innovations in its business. It is of particular importance to implement the quality management system (ISO 9001), to apply Directives, Regulations, guidelines, and harmonized standards, standards of social responsibility, energy efficiency and others.

Also, company must necessarily notice the need for changes, make the necessary decisions, because without changes there is no success.

7. Methods od management, improvement and problem solving in business

There are numerous methods available to manage our business. Managing business means undertaking and implementing processes of change, improvement, and solving problems that objectively arise in the business process.

Only some well-known and most commonly used methods will be listed here:

- Reengineering of business processes (the goal is to do the whole job better, to review the processes and the entire organization - to design a better way of doing business).
- Six Sigma (set of techniques and tools for process and product improvement).
- Pareto or ABC diagram / priority selection method (used for analysis of indicators of business, production, market, procurement, development, etc.)
- Cause and effect diagram or Ishikawa diagram.
- Flow chart (graphic representation of process flow).
- SWOT analysis (for situation analysis and strategy selection),
- Case study (we are looking for an answer to the question of how and why changes in a certain phenomenon occur).

It is not practically possible to manage the business and make the business successful without the use of the mentioned methods and, if necessary, other known methods.

The methods serve us to collect data, analyze them, discover phenomena, events, get an overview of the need for changes, for knowledge, improvements and answers to the questions of what and why to undertake.

Methods are tools in the hands of managers, they enable understanding, creation of decisions, policies, goals, plans, contingency plans, etc., with the aim of achieving the best possible results and ultimately successful business.

8. Conclusion

Practical experiences, scientific content and foundations, views of the situation and numerous unsuccessful companies require processing of this topic, through its questions and content.

The author had a strong will and desire to contribute and present options and opportunities for improving business and performance, which is an obvious need in our reality.

Through the assumptions for successful business, it is visible what makes the company successful, what limits it and what should be done to ensure it.

In particular, the importance of unconditional monitoring, measurement through processes and assurance of data, analysis, information, including indicators that will provide quantitative and qualitative answers to the state of processes, i.e. business and what needs to be done, is pointed out. Without this approach, there is no improvement and change, and therefore no success.

Business entities have a need to monitor and evaluate the quality of their business system. It is essential to identify your plans, strategies, policies and goals. Also, success is directly dependent on the engagement of employees, their knowledge, skills and motivation for success. At what stage of success (medically diagnosed) the company must know, so that it can set its goals, make contingency plans, solve critical and risky situations and ensure that it moves towards success or more successful business.

On the basis of everything treated in this work, the company must define its procedures and steps on how to conduct business. There are numerous methods or so-called techniques available here that provide answers, but also guidelines for what and how to undertake.

It is not possible to manage a company that wants to succeed without applying management methods. Because, by using methods, we improve our business and solve business problems.

Also, with the help of them, we manage changes, resolve conflicts, situations brought about by the changes themselves, and create our business based on constructive decisions, including regulations, aspects of the environment and interested parties.

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Perceived importance of ethics and social responsibility for the economic development

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Abstract. This article analyzes the perception of the importance of ethics and social responsibility for the economic development of Bosnia and Herzegovina, as also the perception of the importance of ethics and social responsibility in relation to long-term gains (PRESOR scale). Using a modified PRESOR scale (Factor 1: Good Ethics Is Good Business) as a measurement tool, the study found that respondents perceive ethics and social responsibility as important factors for economic development, but with limitations. While respondents believe that SR and ethics should be incorporated into strategic goals and plans, they also show doubts about whether business ethics and social responsibility are critical to the survival of a business enterprise. The study concludes that the ethicality of reasons for the application of social responsibility in Bosnia and Herzegovina may represent an additional cause for concern, and suggests that further research is needed in this field. The results also suggest that the long-term incorporation of CSR and ethics in strategic planning has a long way to go before it can surpass the importance of short-term goals. The study highlights the need for further education on CSR and ethics to improve understanding and implementation in Bosnia and Herzegovina.

1. Introduction

The growing interest in the field of CSR has been noted in the last couple of decades, mostly expressed by academia, the business sector, and also government, media, and the general public [1], however little research on this topic has been done in developing countries [2], and especially in Bosnia and Herzegovina. Although a small number, the existing research shows that in Bosnia and Herzegovina, the subordination of CSR to the realization of owners/stockholders' interests exists [3], especially in the case of micro and small enterprises where CSR activities are implemented as investments in certain areas of social responsibility, instead of considering the strategic implementation of the same [4]. "SMEs in developing countries still require more understanding and awareness of the implication of business ethics and its benefits " [5] While the solution for such a low understanding of CSR and ethics might be found in further education, given that educational programs in CSR can act as a medium for improvement in multiple fields of ethics and CSR in both private life and business [6], it still remains unknown does the current academic educational system in Bosnia and Herzegovina influence the understanding of CSR and ethics, in which way and with how big intensity. Therefore, we believe that it is important to investigate the perception of the importance of ethics and social responsibility.

2. Literature review

The definition of CSR is both complex and complicated [7], and mostly it remains ambiguous [8]. Also, it must be noted that in developing countries, CSR is most commonly associated with philanthropy or charity, where making an economic contribution is often seen as the most important and effective way for businesses to make a social impact [9]. The definitions of CSR also often contain in themselves the topic of economic development, where The World Business Council for Sustainable Development [10] defines corporate social responsibility as „the continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large."

In the context of economic growth, development, and ethics [11] claim that economic growth is a necessary condition for economic development, however, economic growth without „respecting ethical principles is not sufficient to ensure economic development".

According to Săvoiu and Ţaicu [11] „business ethics is always positively related with socio-economic development. Either the social or economic development of the society will be guaranteed if the ethical issues are obeyed in the country". In the context of everything stated above, we have formulated a research question that is as follows: are ethics and social responsibility perceived as important for the economic development of the country in Bosnia and Herzegovina?

A previous study on the perception of the importance of ethics and social responsibility [3] that was conducted on the population of SME managers from Bosnia and Herzegovina showed that managers see ethics and social responsibility as important as long as they do not have to sacrifice something for them, with existing subordination of ethics and CSR to the interests of owners of the companies. It is also concluded that SME managers in Bosnia and Herzegovina „need more understanding of the importance of ethics and social responsibility for creating long-term firm value" [3] with recommendations that further questions should be asked to reveal the degree of understanding of the ethics and social responsibility of the respondents.

The current study consists of the following parts: literature review, research methodology, results, discussion, and conclusion.

3. Research methodology

For the purposes of this study, we used 7 statements from the PRESOR scale [13]. Singhapakdi et al. [13] [14] „developed the PRESOR scale to measure one's perceptions regarding the importance of the ethics-and-social-responsibility components of business decisions" [15]. Apart from being already tested on respondents from Bosnia and Herzegovina [3], the PRESOR scale developed by Singhapakdi et al. [14] was also used to measure relationships between ethics education, moral attentiveness, and the perceived roles of ethics and social responsibility [16]; the relationship between perceived roles of ethics and social responsibility, internal CSR and employee engagement of academicians [17]; ethics, social responsibility, and business performance in transition economy [18], and many more.

In this study, all 7 used statements were part of the first dimension of the PRESOR scale developed by Singhapakdi et al. [13]. „The seven items describe the importance of ethics and social responsibility in relation to long-term gains such as survival, long-term profitability, and organizational competitiveness. This dimension suggests that individuals will consider ethics and social responsibility as important because of its impact on the ultimate survival and competitiveness of the firm" [12].

Apart from the named statements, the respondents have been offered to give their evaluation on the following statements:

- Ethics is important for the economic development of the country;
- Ethics is important for the development of a company;
- Social responsibility is important for the economic development of the country; and
- Social responsibility is important for the development of a company.

In the end, respondents have been asked to self-evaluate their understanding of ethics and corporate social responsibility (from „1 – I absolutely don't understand it" to „5 – I absolutely understand it").

4. Results

A total of 76 completed survey questionnaires were collected. Four survey questionnaires were discarded after the data review. The results presented in the paper represent the responses from 72 survey questionnaires. The basic demographic data of respondents are presented in Table 1.

Table 1. Demographic analysis of respondents.

		Frequency (valid)	Percent (valid)
Respondents by gender	Male	17	25
	Female	51	75
Student status	Student	42	58,3
	Non-student	30	41,7
Status of employment for non-students	Employed	25	34,7
	Unemployed	12	16,7

In the next part of the survey respondents were asked to evaluate 7 PRESOR scale statements and added statements in the form of a Likert scale. The results in the form of mean values are presented in Table 2.

Table 2. Descriptive statistics of the survey.

Statement	Min	Max	Mean	Std. Dev.
Ethics is important for the economic development of the country.	1	5	4.29	0.926
Social responsibility is important for the economic development of the country.	2	5	4.44	0.886
Ethics is important for the development of a company.	2	5	4.32	0.836
Social responsibility is important for the development of a company.	1	5	4.32	0.932
PRESOR 1	1	5	4.49	0.872
PRESOR 2	1	5	3.28	1.278
PRESOR 3	1	5	4.26	1.007
PRESOR 4	2	5	4.18	0.828
PRESOR 5	1	5	3.69	1.146
PRESOR 6	1	5	4.50	0.856
PRESOR 7	2	5	4.26	0.757

As can be seen in Table 2., all statements have their mean values scored above 4, except two PRESOR statements: „Business ethics and social responsibility are critical to the survival of a business enterprise (Me = 3.28)“, and „Business has a social responsibility beyond making a profit (Me = 3.69)“. The highest mean value has been achieved at the statement „Corporate planning and goal-setting sessions should include discussions of ethics and social responsibility (Me = 4.50)“. According to the Likert scale interpretation criteria ([19]; in [20]), we can conclude that respondents express a „strong positive“ perception when it comes to the inclusion of ethics and social responsibility in strategic planning, and at the same time „inconclusive negative“ for the statement „Business ethics and social responsibility are critical to the survival of a business enterprise“.

The exploratory factor analysis (EFA) has confirmed a one-factor solution for seven items from the PRESOR scale. The results of the EFA suggested that one factor explained 46.28% of the variance; KMO = 0.85; Bartlett's Test of Sphericity is significant ($\chi^2 = 127.53$; df = 21; $p < 0.05$). All items have factor loading above 0.4. In a study by Singhapakdi et al. [13], this factor was labeled "Good Ethics Is Good Business".

There are statistically significant and positive correlations among the factor „Good Ethics is Good Business“ and statements: „Ethics is important for the economic development of the country“; „Ethics is important for the development of a company“; „Social responsibility is important for the economic development of the country“; and „Social responsibility is important for the development of a company“ with further information present in Table 3.

Table 3. Correlations and significance coefficients.

	Good Ethics is Good Business	EED	SRED	EDC	SRDC
Good Ethics is Good Business	1				
Ethics is important for the economic development of the country.	0.411**	1			
Social responsibility is important for the economic development of the country.	0.424**	0.664**	1		
Ethics is important for the development of a company.	0.547**	0.660**	0.699**	1	
Social responsibility is important for the development of a company.	0.629**	0.674**	0.712**	0.915**	1

Analyzing data presented in Table 3. we notice a highly positive and statistically significant correlation between statements that measured the importance of social responsibility ($r = 0.629$; $p < 0.01$) and ethics ($r = 0.547$; $p < 0.01$) for the development of a company and factor named „Good Ethics Is Good Business“. Also statistically significant and positive, although lower, correlations have been found between the importance of social responsibility ($r = 0.424$; $p < 0.01$) and ethics ($r = 0.411$; $p < 0.01$) for the economic development of the country and the factor named „Good Ethics Is Good Business“. There is no statistically significant difference in the achieved means with regard to whether the respondents are students or not, nor is there a statistically significant difference with regard to the gender of the respondents.

5. Discussion and limitations

SR and ethics should be incorporated into strategic goals and plans, but there is a lack of higher intensity of agreement that they are critical to success in the following: „Business ethics and social responsibility are critical to the survival of a business enterprise“ (Me = 3.28); and „Business has a social responsibility beyond making a profit“ (Me = 3.69). At the same time, the highest mean value is achieved at the statement „Corporate planning and goal-setting sessions should include discussions of ethics and social responsibility“ (Me = 4.50).

Analyzing the importance of ethics and social responsibility, respondents find that ethics and social responsibility should be included in strategic planning and goal setting (Me = 4.50), but they still show doubts regarding if business ethics and social responsibility are critical to the survival of a business enterprise (Me = 3.28). The role of both social responsibility and ethics in the economic development of the country are found important to respondents, but higher relevance is seen to be given to the social responsibility for the economic development (Me = 4.44; SD = 0.886) than the ethics (Me = 4.29; SD=0,926). Săvoiu and Ţaicu [11] state that economic growth without respect for ethical principles is not a sufficient guarantee of economic development. According to the results of this study, respondents consider ethics and social responsibility to be important for the economic development of the country.

Also, achieved results with the dimension Good Ethics Is Good Business suggest that respondents perceive ethics and social responsibility as important in relation to long-term gains.

The results regarding the achieved values on the first dimension of the PRESOR scale are consistent with the findings of a previous study indicating higher mean values on the first dimension of the PRESOR scale in Bosnia and Herzegovina, based on a sample of managers in small and medium-sized enterprises [3]. Also, in the study of Ćatić – Kajtazović et al. [3] „the most significant difference in comparison of means ($t = 8.016$; $P < 0.0001$) was on the item 'Business has a social responsibility beyond making a profit' in favor of Croatian managers". As could be expected, there is a statistically significant correlation between the dimension „Good Ethics Is Good Business" and respondents' perception of the importance of social responsibility and ethics in the economic development of the country.

This study has several limitations. The first and foremost is related to the number of participants in the research, which is why an exploratory factor analysis (EFA) was not conducted on all the statements used in the survey questionnaire. Furthermore, measuring participants' perception of the importance of ethics and social responsibility in the economic development of the country and the development of enterprises solely based on the provided four statements in the survey questionnaire can be challenging. Therefore, it is recommended to expand and replicate such studies with additional statements. Another limitation of this study is the lack of a solid theoretical foundation regarding the link between ethics, social responsibility, economic development, and the PRESOR scale.

6. Conclusion

The results of this study demonstrate that in Bosnia and Herzegovina, social responsibility and ethics are perceived as important for the economic development of both the country and companies, although there is a stronger belief in their benefits for companies. We can conclude that respondents express a „strong positive" perception when it comes to the inclusion of ethics and social responsibility in strategic planning, and at the same time „inconclusive negative" for the statement „Business ethics and social responsibility are critical to the survival of a business enterprise". Overall, these findings indicate a limited understanding of the advantages of SR and ethics for company development. We firmly believe that this state of affairs can be improved through well-structured and organized education in these fields. Conversely, the results also indicated that student status did not yield any statistical difference in the research, suggesting the need for further investigation and restructuring of the current education on SR and ethics in universities of Bosnia and Herzegovina.

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Physico-chemical properties of the Una River based on abiotic tests upstream and downstream of the city of Bihać

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Abstract: The tests of the abiotic parameters of the River Una were carried out at two sites in two seasons in this paper, in order to determine the ecological status of this river. The selected sites are upstream from the city of Bihac – dvoslap Lohovo and downstream from the city of Bihac – Kostela. The samples were taken in two seasons, late winter (March) and late spring (May). Physic – chemical and microbiological analysis were carried out at the Biotechnical faculty of the University of Bihac.The results show that the quality of the River Una upstream from the city of Bihac is in a very good ecological condition. Downstream from the city of Bihać, the contents of physic – chemical parameters are increased which indicates anthropogenic impact. The number of Escherichia coli is also increased downstream from Bihac, but it doesn't exceed permitted values. By determining the content of heavy metals (Cd and Pb), a slightly higher value of Cd (0,004 mg/L) was found downstream from the city of Bihac, but it doesn't indicate a significant pollution. The research carried out in this paper indicates that the River Una is in a better ecological condition upstream than downstream from the city of Bihac, because of the anthropogenic impact as the result of releasing technological and communal wastewater, but although the ecological condition is in a worse state downstream, no parameter exceeds permitted values.

1. Introduction

Surface waters are complex multicomponent systems, the study of which requires a multidisciplinary approach. The specificity and complexity of the chemical composition of surface waters and quality indicators as a result of dissolved mineral and organic substances, gases, suspended substances and microorganisms emphasize the importance of applying methods for their assessment by finding a common factor that encompasses quality as a whole. If the water temperature rises above normal, it usually indicates the presence of industrial wastewater, and a drop in water temperature often reveals the presence of a deep underground water source (Tuhtar, 1990). Various microorganisms can be present in natural and waste water - bacteria, viruses, protozoa. Microbiological testing, however, generally includes only certain indicator microorganisms, which indicate the occurrence of pollution, and sometimes also its source. Coliform bacteria are used as indicator microorganisms, which, however, are not specific indicators of fecal pollution. Therefore, in addition to total coliform bacteria, thermotolerant coliforms - faecal coliform bacteria (typical representative of *Escherichia coli*), streptococci and enterococci of fecal origin (*Enterococcus*), as well as sulfate-reducing clostridia (*Clostridium perfringens*) are additionally tested (Vučijak et al.,2011). Many pathogenic bacteria are present in the environment in small numbers and their detection is difficult (Henze et al., 2008) . Coliform bacteria are mainly opportunistic pathogens, which means that infection caused by coliform bacteria can occur in

case of weakened immunity. The main characteristic of the "Beauty of Krajina" is clean water and numerous travertine waterfalls that captivate with their beauty, as well as the canyons and gorges through which they flow (Džankić et al., 2006). The Una Valley has the characteristics of a recent polyphase evolutionary development, as evidenced by the growth of travertine barriers that broke the longitudinal profile into several sections (Spahić, 2003). Many pathogenic bacteria are present in the environment in small numbers and their detection is difficult (Henze et al., 2008) . Coliform bacteria are mostly opportunistic pathogens which means that an infection caused by coliform bacteria will occur in the case of a weakened immunity. Total coliforms, staying in the external environment, lost the ability to tolerate temperatures of 44.5 °C are a sign of older fecal pollution (Stilinović and Hrenović, 2009). Waste as a pollutant has a negative impact on the environment and people's health. By dumping waste in watercourses, the riverbed narrows, and thus increases the risk of flooding during heavy rainfall (Knežević at all., 2012). The protection of water resources is of great importance not only from the aspect of preserving a healthy environment, but also from the aspect of supplying all areas of human activity with water (Đukić at all., 2011.).

2. Material and Methods

When determining the quality of the Una River at certain locations, field and laboratory tests were carried out. On the field (In-situ), the pH value, temperature, electrical conductivity and dissolved oxygen were measured. Microbiological indicators (Escherichia coli) and physico chemical indicators (temperature, pH value, electrical conductivity, dissolved oxygen, BOD5, COD, ammonium ion, nitrates, nitrites, chlorides, sulfates, phosphates, cadmium and lead).The physical and chemical parameters that were tested on the water samples are shown in Table 1. The conditions in which the analysis of heavy metals were performed are shown in Table 2.

Table 1. Physical and chemical parameters.

Parameter	Unit of measure	Method
Temperature	°C	Electrochemical
pH		Electrochemical
Electrical conductivity	µS/cm	Electrochemical
Dissolved oxygen	mg/lO_2	Electrochemical
COD	mg/lO_2	Spectrophotometric
BOD_5	mg/lO_2	Electrochemical incubation for 5 days on the 20th °C
Ammonium ion NH4+	mg/l	Spectrophotometric
Nitrates, NO_3	mg/l	Ion chromatography
Nitrites , NO_2-	mg/l	Ion chromatography
Chlorides, Cl^- -	mg/l	Ion chromatography
Sulfates	mg/l	Ion chromatography
Phosphates	mg/l	Ion chromatography
Cadmium (Cd)	mg/l	AAS (atomic absorption spectrometry)
Lead (Pb)	mg/l	AAS (atomic absorption spectrometry)

Table 2. Recommended conditions for analysis on the Atomic Absorption Spectrophotometer (AAS)

Element	Pb	Cd
Flame	air-acetylene	air-acetylene
Wavelength (nm)	283,3 nm	228,8 nm
Silt(nm)	0.7	0.7
Mode	AA-BG	AA-BG
Burner	10 cm	10 cm
Nebulizer	High sensitivity	High sensitivity
Signal Measuremet	Peak area	Peak area

Calibration metods	Linear / zero	Linear / zero
Stock Standar Solution. (mg/l)	Lead 1000 mg/l; St. 10,	Cadmium1000mg/l ; St. 2

The presence of Escherichia coli bacteria was detected by the membrane filtration method using three dilutions (100 ml, 1 ml, 0.1 ml) on endoagar. The samples were incubated at a temperature of 37°C for 24 and 48 hours, respectively. 1 ml, 10 ml and 100 ml samples were filtered for both research sites in two seasons (late winter and late spring) in a membrane filtration device with sterile funnels and a vacuum pump (Pall-Gelman Sciences, model no.: 15400).

3. Results and Discussion

The measured values of the analyzed physical and chemical parameters (Table 3.) differ according to the seasons and locations of the research.

Table 3. Results of physical and chemical analyses

Parameter	Unit of measure	UPSTREAM		DOWNSTREAM	
		March	**May**	March	**May**
Temperature	^oC	8,4	11,2	10,1	13,1
pH		7,6	7,8	7,7	7,3
Electrical conductivity	µS/cm	407	453	363	509
Dissolved oxygen	mg/lO_2	8,7	9,82	8,0	7,8
COD	mg/lO_2	4	1,7	7	13
BOD_5	mg/lO_2	0,8	0,9	2,2	3,2
Ammonium ion $NH4^+$	mg/l	0,08	0,11	0,21	0,28
Nitrates, NO_3	mg/l	1,097	1,945	2,003	2,238
Nitrites , NO_2^-	mg/l	-	-	-	-
Chlorides, Cl^- -	mg/l	2,437	4,118	3,937	4,982
Sulfates	mg/l	11,541	12,352	15,752	15,772
Phosphates	mg/l	0,02	0,02	0,04	0,05
Cadmium (Cd)	mg/l	0,002	0,003	0,004	0,004
Lead (Pb)	mg/l	-	-	-	-

According to the Decision on the characterization of surface and underground waters, reference conditions and parameters for water condition assessment and water monitoring ("Official Gazette FBIH", no. 1/14) and Law on Waters ("Official Gazette of the Federation of Bosnia and Herzegovina", number 70/06) and by-laws on the categorization of waters, the Una River in its upper course upstream of the city of Bihać belongs to Class I waters, and in its downstream course to Class II waters. Considering all the measured physico-chemical and microbiological parameters, it is categorized as still water in a very good ecological condition, with a slight increase in the concentrations of the measured parameters in the downstream stream, which indicates anthropogenic action. The measured temperature in the river Una does not indicate a deviation from the average. At the upstream site (March – 8.4°C, May – 11.2°C) during both sampling seasons slightly lower values were recorded compared to the downstream site (March – 10.1°C, May – 13.1°C).

Neutral-basic waters are those in which the pH value is rarely below 6, and in a number of cases it can be above 10, while waters with an acidic reaction are those with a pH lower than 5 (Piria and Tomljanović, 2006). The water of the Una River belongs to neutral-alkaline waters. In the samples, pH values range from 7.3 – 7.8 (Table 3), which is typical for karst rivers rich in calcium and magnesium ions. The measured pH values in the water of the Una River are optimal for effective biological productivity. A slight drop in pH is observed downstream from the city of Bihać, which indicates organic

pollution, elevated concentrations of nutrient salts, as well as coliform bacteria, however, according to the Water Act ("Official Gazette of the Federation of BiH", number 70/06) and Directive 2000/60 /EC, the recorded decrease in pH value does not lead to deterioration of the ecological state of the water. The obtained results indicate that in the downstream stream the concentration of dissolved oxygen is slightly lower and amounts to 8.0 mg O_2 L-1 in March, and 7.8 mg O_2 L-1, while in the upstream stream the concentration of dissolved oxygen in March was 8.7 mg O2 L-1, and in May 9.82 mg O2 L-1 (Table 3). The COD results in the river Una indicate a worse water quality of samples taken downstream (March – 4 mg O_2 L-1, May – 1.7 mg O_2 L-1, while the COD values in the upstream stream were 7 mg O_2 L in March -1, and in May 13 mg O_2 L-1) (Table 3.) and confirm the significant anthropogenic influence on the water quality of the Una River.

The amount of nitrate in the upstream of the Una River was 1.097 mg/l in March, and 1.945 mg/l in May. As for the downstream flow, the values were 2.003 mg/l in March and 2.238 mg/l in May. No large amounts of phosphate were found in the Una River samples, and the values found in the upstream flow in March and May were 0.02 mg/l, and in the downstream in March 0.04 mg/l, and in May 0.05 mg/l. Amounts of ammonia, which occurs in water as a product of the decomposition of organic substances, is a very strong poison that affects the central nervous system of all types of fish (Piria and Tomljanović, 2006), downstream ammonia values were 0.08 mg/l in March and 0. 11 mg/l in May, and upstream 0.21 mg/l in March and 0.28 in May.

The results of heavy metal research are shown in Table 3 and show that there is no presence of lead (Pb) in the river Una, while the content of cadmium (Cd), in both research periods and both locations, was below 0.1 mg/l (upstream: March – 0.002 mg/l, May – 0.003 mg/l; downstream: March – 0.004 mg/l, May 0.004 mg/l). According to the results of the microbiological analyzes shown in table 4, we conclude that the values do not exceed the reference value of $<10^3$ in any sample except in the month of May in the downstream of the Una River. Which indicates good water quality.

Table 4. Results of microbiological analysis .

	Reference values	**UPSTREAM**		**DOWNSTREAM**	
		March	**May**	**March**	**May**
Total coliforms (***Escherichia coli***)	$<10^3$	$< 10^1$	$>10^1$	$>10^2$	$>10^3$

4. Conclusion

The conducted researches of the Una river in the localities upstream and downstream of the city of Bihać included physico-chemical and microbiological analysis. Based on the obtained results of the specified research, which were conducted in two seasons, the following can be concluded:

- Examination of the quality of the river Una in the part of the stream upstream of the city of Bihać indicates that the water is in a very good ecological condition according to the Decision on the characterization of surface and underground waters, reference conditions and parameters for water condition assessment and water monitoring (Official Gazette FBIH, no. 1-14) .
- The results of the analysis of the physical and chemical parameters of the Una River show that the contents are slightly increased in the downstream course of the Una River, which is an obvious anthropogenic impact, which is a consequence of the discharge of technological and communal wastewater for which there was no adequate purification system until recently. By putting into operation the wastewater treatment plant in the city of Bihać, anthropogenic impact will be reduced.
- Analysis of the content of heavy metals (Cd and Pb) in the river Una shows that the content of Cd is higher downstream from the city of Bihać, while the content of Pb has not been identified. The results indicate that Cd concentrations are low and that there was no significant pollution of the Una river watercourse. The results are in accordance with the Regulation on hazardous and harmful substances in water ("Official Gazette FBIH", No. 43/2007).

- Microbiological analysis (determination of E. coli) shows that the number of E.coli increases in the downstream of the Una river, which also indicates anthropogenic influence, but does not exceed the permitted values.

It is necessary to thoroughly monitor the quality of the Una River and immediately react to any change caused by anthropogenic influence. Only by accurate determination and systematic monitoring of parameters, we can react in a timely manner and preserve this great wealth of ours.

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Continuous Quality Improvement in Higher Education Institutions

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Abstract. Adopting the concept of internal users' quality management system will change the culture of the higher education institution in several useful ways, such as: improving inter-functional cooperation, abolishing the necessary administration, encouraging the morale of students as well as teaching and administrative staff. Continuous improvement is one of the critical aspects of total quality management. It is important to understand that continuous improvement is not a project, a task to be done and then forgotten. The quality system never ends. It is the way to TQM, which must be continuously improved. Quality improvement in higher education institutions consists of the following processes: improvement of teaching, scientific research and knowledge transfer. Understanding the philosophy of continuous business management at the level of a higher education institution is a strategic goal of a higher education institution. The objective is for students to master critical thinking and problem-solving skills. Students should be provided with quality education through new programs that will prepare them for the labor market, the continuation of the second and third cycle of studies, and prepare them for life in the 21st century.

1. Introduction

Observing the development of society from its inception to the present day, it can be said that the quality of education was always taken care of to a greater or lesser extent, which depended on the level of social development. The degree of social development depends on the quality of higher education. The industrial revolution led to the development of large companies with mass production, with the use of modern machines and technology. This type of production requires a high level of product quality and the need for quality management. The key factor affecting the level of quality is a highly educated and competent staff with highly professional knowledge [1].

The goal of quality assurance in the system of higher education, scientific and artistic activities is the continuous assurance and improvement of the quality of the work of higher education and all scientific workers working in scientific institutes, as well as monitoring the quality of study programs and studies at higher education institutions, in accordance with European and international quality assurance standards in the field of higher education and scientific activity. Quality assurance in the higher education system of scientific and artistic activities is carried out by the system of internal assurance and quality improvement and the system of external quality evaluation and accreditation.

The purpose of the standards and guidelines is to:

- To improve the education available to students at higher education institutions in the European Higher Education Area;

- To assist higher education institutions in quality management and quality improvement, thereby helping to justify their institutional autonomy;
- To create a basis for the work of quality assurance agencies;
- To make external quality assurance more transparent and easier to understand for everyone involved in it.

The objectives of the standards and guidelines are:

- To encourage the development of higher education institutions that will encourage dynamic intellectual and educational activities;
- To be a source of help and guidance for higher education institutions and other relevant agencies in developing their own culture of quality assurance;
- To inform and increase the expectations of higher education institutions, students, employers and other stakeholders from the process and outcomes of higher education;
- To contribute to a common reference framework for higher education provision and quality assurance in the European Higher Education Area [2].

2. Quality assurance in higher education

Higher education in Bosnia and Herzegovina has been recognized as a priority area of special public interest. Concern for the quality of education and its development is becoming a priority in education policies at all levels in Bosnia and Herzegovina. Public universities in Bosnia and Herzegovina have begun the reform and introduction of quality assurance policies and practices even before the inclusion of Bosnia and Herzegovina in the Bologna Process in 2003. During the 2003/2004 academic year, all existing public universities in Bosnia and Herzegovina were included in the institutional assessment of the European University Association (EUA).

Key documents in the field of quality assurance in higher education in Bosnia and Herzegovina are Standards and guidelines for quality assurance in higher education and recommendations for the implementation of quality assurance in higher education in Bosnia and Herzegovina.

An important key document defining the quality assurance system in Bosnia and Herzegovina is the Framework Law on Higher Education in Bosnia and Herzegovina adopted in 2007. Bosnia and Herzegovina signed the Bologna Declaration in 2003 at the Ministerial Conference in Berlin, but it was only with the adoption of the Framework Law on Higher Education in Bosnia and Herzegovina that progress was achieved in the sense of establishing a common legal framework for the entire Bosnia and Herzegovina, but also a decisive turning point in supporting higher education reforms in Bosnia and Herzegovina according to the principles and standards of reform processes in the European Higher Education Area [3].

The framework law established the organization of higher education in Bosnia and Herzegovina and the responsibility of the competent authorities, established bodies for the enforcement of laws and international obligations, the agency for the development of higher education and quality assurance, and the Rector's Conference in Bosnia and Herzegovina.

Along with the Ministry of Civil Affairs of Bosnia and Herzegovina and the Conference of Ministers of Education of Bosnia and Herzegovina, it has an established institutional network with clearly defined competencies, responsibilities and tasks that provide favorable conditions for the implementation and development of higher education based on strategic goals, European standards and Bologna principles. The Agency for the Development of Higher Education and Quality Assurance has developed reference documents, and criteria for accreditation in higher education institutions [3].

The higher education institution takes care of the execution of the tasks for which the organization exists and the maintenance of the organization or the people and their needs. The basic function of higher education institutions is to meet the needs of employees who work in higher education institutions.

3. The process of improvement in a higher education institution

When a higher education institution meets the requirements of the ENQA standard and receives accreditation, it is necessary to create an action plan for the implementation of the recommendations proposed by the committee of national and international experts for accreditation. Therefore, it is

necessary to improve all processes at the higher education institution. These improvements should be carried out continuously by creating an integrated quality management system, implementing the requirements of Standards ISO 9001, ISO 14001, ISO 45001, ISO 26000, ISO 22301 and ISO 31000. Improvement processes should include the teaching process, the process of scientific-research work and the process of knowledge transfer by establishing the process of introducing continuous improvements in the quality management system. These processes must include those methods and measurement parameters that correspond to the specific process. After a detailed analysis of the aforementioned minimum requirements for the quality management system, a number of measures are possible, such as: identification and documentation of existing processes, application of appropriate measures such as modern process management, application of methods and tools for control and process improvement, planning and implementation of further activities towards achieving TQM. The integration of measures with the aim of achieving quality should be explained in detail through the rules of procedure on quality and standard procedures, and set on the principles of the improvement cycle. A four-part cycle typically forms the basis of most continuous improvement approaches. That cycle was developed by quality expert Walter Shewhart. It is a continuous process. It has no beginning and no end. Today it is known as Deming's PDCA circle.

The PDCA cycle was originally described by Walter Shewhart during the 1930s and later adopted by W. Edwards Deming. The model provides a framework for improving the process or system. It can be used to guide improvement projects or to develop specific projects once an area for improvement has been identified. The PDCA cycle was created for use as a dynamic model. The end of one cycle is the beginning of the next. The process can always be reanalyzed and new testing of the change can begin. This continuous cycle of change is shown on the improvement slope. By using what we learned in one PDCA cycle, we can start a new, more complex cycle.

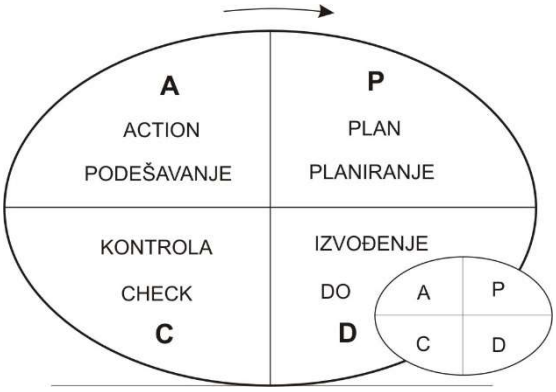

Figure 1. Deming circle of advancement or improvement.

PLAN – change or test with the aim of improvement.
In this phase, you analyze what you intend to improve by looking for areas that have opportunities for change. The first step is to choose the area that offers the greatest return for the effort you need to make, the greatest return on the dollars invested. You can use a Flow Map or a Pareto Map to identify these areas of change.
DO – perform a change or test.
Implement the changes you decided on in the planning phase.
CHECK – results of what was learned? What went wrong?
This is the most important step of the PDCA cycle.
After you have implemented the change for a short period of time, you need to determine how well it is working. Does it really lead to improvement in the way you hoped? You need to decide on several benchmarks by which you can measure the level of improvement. Certain graphs can be helpful when measuring.

ACTION – Accept the change, reject it or go through the cycle again. After planning the change, implementing it and monitoring it, you must decide whether it is worth going ahead with the change. If it is taking up too much of your time, was difficult to follow, or didn't even lead to improvement, you need to consider ditching the change and planning a new one. However, if the change has led to the desired improvement or result, you must consider expanding the trial to other areas or slightly increasing the complexity. This brings you back to the planning stage and can be the start of the improvement.

4. Quality improvement

This concept emphasizes the pursuit of continuous improvement and assumes the fact that the achievement of quality is at the center of the academic ETHOS (ethics, morals, beliefs) and that members of the academic community themselves know best what quality in higher education is. The main disadvantage of this concept is that it is difficult to ‘’measure’’ improvements and that it is very difficult to recognize the evidence of improvement in public. The understanding of quality and the basic settings of certain concepts are mixed, intertwined and changed due to constant changes in the environment in which higher education institutions operate, as well as due to the increase in knowledge within higher education systems and institutions that are gradually developing their own concepts of quality and models. In addition to evaluation and quality management in the system, which has already developed agency for the development of higher education and quality assurance, there is a constant tension and pressure to align with institutional approaches to quality [4].

If we want to improve the process of teaching, scientific research work and knowledge transfer with the aim of effectively improving these processes in higher education institutions, we must have qualified heads of processes and their mutual team cooperation. This includes all the management of the higher education institution, namely: rector, vice-rectors, deans, vice-deans, department heads and quality management managers, as well as teaching staff and administration. The procedure should start by understanding exactly which processes we want to continuously improve and through which projects. This will help establish the goals of the entire procedure. In accredited higher education institutions where ENQA standards have been implemented and verified, an adequate process has five properties: defined process, controlled process, efficient process, cost effective process and adaptive process. Process management projects will be at the heart of your TQM program. Process management is not something that should be rushed or undertaken unplanned. This process must be well planned, implemented, controlled and improved. It is best to start with the implementation of BAS EN ISO 22301 after the ideas of the total quality structure have been adopted at the higher education institution. Firstly, it is necessary to ask the teams what they have done to improve the process. Check if we are ready to start the improvement process? Is the team established? Are its members used to teamwork?

It's usually a good idea to start with a team that already has experience with quality improvement or problem-solving projects. The team would have to be trained in the concepts of total quality and process management. All team members should know the tools and methods for improvement. Always keep in mind whether the project has significant potential. Do not initiate the improvement process in areas that do not have a major impact on the results and learning outcomes in the higher education institution.

Will the improvement project be visible? Will a large number of employees notice the success? Instead of setting employee expectations with interest in continuous improvement, it is better to let the learning outcomes speak for themselves. Success will generate additional interest. The process management team will be composed in a manner similar to the quality improvement teams. Essentially as total quality programs progress, continuous improvement projects will become the primary responsibility of these teams. The requirements of the interested parties should be analyzed through the improvement program, as well as every aspect of quality. The process starts and ends with the students. It must be absolutely clear to the team and all employees who is the user of the output of the process and what is to be given to the students through the implementation of the syllabus.

This can be difficult for teams involved in services such as legal services, student services, accounting and administration. However, there is no way that work can be seen as a process if the

student is not in the first place. In order to benefit from this project for continuous improvement, we need to have clear input data about the students, which high school they graduated from and with what success, what success they achieved in the entrance exam, a record of conversations with students to know what they need, why is it important for them to receive degree from the higher education institution in the first, second and third cycle of education, whether they have received a scholarship and from which organization, and for which sector they are being trained. From the beginning to the end of education, the higher education institution must determine the quality indicators that will be continuously monitored. This is a significant step for continuous quality improvement. Some colleges have been operating for years without consulting those benefit from their graduates.

The data obtained from the analysis of student requests is a real discovery of deficiencies in a higher education institution. Sometimes it is determined that the student does not need the subject material at all because it is out of date and is studied according to literature that is not for use. For the above reason, continuous control of the entire program and changes in accordance with the contemporary trends is necessary. Experts recommend that teams carry out this kind of analysis both in the teaching process and in teaching research work and knowledge transfer. What does the process require in terms of the exchange of experiences in the economy? How to help in cooperation with the economy in strengthening learning outcomes? All activities in this project must be documented. Nine steps to improve and advance the quality system were observed. These are: extracting data, processing data, choosing activities, defining goals, choosing a team, determining corrective measures, implementing corrective measures, evaluating results, and documenting slow-moving corrective measures.

5. Risk management

Risk management is the process of identifying and processing risks, taking into account the context and goals of the organization, the requirements of interested parties, as well as other issues and requirements of the quality management system, including defining control activities as a preventive measure, the goal of which is to avoid unwanted events and monitor their implementation.

During the risk identification phase, the question arises, what could happen that would affect the established goals? These are certain obstacles, events, and circumstances that can prevent the achievement of the goal. When identifying risks, the following methods can be used: experiential method, brainstorming method or SWOT analysis. In order to take into account all aspects and areas when determining risks, risks can be grouped into five main groups:

1. Risks related to communication and information
2. Risks related to the external environment
3. Risks related to employees and the organization
4. Risks related to planning, processes and management systems
5. Risks from the aspect of legality and correctness

It is necessary to provide a description of each risk, which should contain the cause of the occurrence of the risk and its impact on the realization of the company's goals (Table 1).

For example, the risk that can be identified is ‘’delay of raw materials or non-compliance of suppliers with requirements’’, which can affect production stoppage, non-fulfillment of product manufacturing deadlines and other non-compliances in production. Such influence can have major consequences for the organization's operations. The cause of the occurrence of the mentioned risk is the non-compliance of the supplier's work with the requirements of the customer (organization) [6].

Table 1. Risk identification.

Activity	RISK IDENTIFICATION		
	Risk	Cause	Impact

6. Factors influencing quality in higher education

The quality of learning outcomes is influenced by many human and technological factors. The impact on the quality of learning outcomes is always the teaching staff (people), but since they are often different, it is a combination of human and technological factors that are interdependent. Human factors imply the characteristics of participants in the processes such as education, knowledge, experience, abilities, and skills that differ from teacher to teacher. The quality of teaching staff should be better than the quality system, which means that the quality system is built by people [7].

Technological factors represent learning resources, equipment, materials, funding for innovation and development. Two factors that should affect the quality of teachers are education and experience. However, experience has shown that students do not gain knowledge increased in proportion to teaching titles and experiences, which leads to the conclusion that there are different conditions for advancement in higher education institutions in Bosnia and Herzegovina. Still, advances in all higher education institutions are associated with significant implications for costs in higher education. Non-compliance with the Framework Law on Higher Education in Bosnia and Herzegovina is directly at the expense of the student population.

7. Conclusion

Continuous improvement of quality in higher education implies constant engagement of all employees, and knowledge of the responsibility matrix and constant exchange of experiences in the organization. Quality improvement is part of quality management in the function of the quality improvement process and a set of actions that are understood in the entire higher education institution with the aim of increasing the activity of the process, in order to achieve success among students. Quality improvements are achieved with the application of certain management principles and methods. The Deming circle has four basic management functions in the form of a circular PDCA cycle, namely planning – execution – control – improvement that leads to advancement and continuous improvement of quality.

Obtaining a certificate should not be the ultimate goal, but in the spirit of the culture, we go further through continuous improvements using tools and methods for improvement towards TQM, i.e., employment excellence. The external benefits of an internationally recognized certified quality system and an accredited university represent entry into the company of the best and the possibility of cooperation with world-class certified and accredited universities in conditions where special proof is not required.

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Morphological characteristics of the studied isolates Alternaria spp

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Abstract. Study of morphological characteristics of Alternaria spp. isolated from carrots included the study of macroscopic and microscopic characteristics of selected monosporial isolates of these fungi. Monosporic cultures of Alternaria spp. 10 days old, raised on a potato-dextrose agar at a temperature of 25 °C, were used for these studies. The morphology or phenotype of the tested isolates of Alternaria spp., isolated from carrots grown in Bosnia and Herzegovina and Serbia, were determined based on a visual description of the macroscopic properties of pure cultures (colonies), microscopic properties of individual structures and biometric values of colony diameter and size of conidia. By studying the morphological characteristics of the selected isolates, it was determined that group A isolates (FM-15 and BM-2) showed the most similarities with isolate CLA-108, which was previously identified as the standard for the A. dauci species. These isolates produced a pigment in the substrate and coloured it pinkish-reddish, and in situ formed individual conidia in the form of an elongated ellipse, which have a very characteristic long pointed bright beak, which gradually narrows and sometimes forks in one place. The average size of conidia of the tested isolates was 69.59–71.30 x 19.77–20.43 μm, while the number of septa varied from 5 to 13. The length of the beak is 1 to 3 times longer than the body of the conidia and ranged from 67.65 to 388.35 μm. The ratio of length to width of conidia varied from 3.45 to 3.57. Unlike them, isolates of group B (IM-14 and Mr-114) showed the most similarities with isolate Aa-82, which was previously identified as the standard for the species A. alternata. These isolates did not produce pigments or stain the substrate, and in situ formed conidia in the form of long branched strings, which are of different shapes, regularly ellipsoidal, round or elongated with a short conical beak or without a beak. The average size of the conidia of all three isolates were 15.17–39.57 x 7.45–14.90 μm, while the number of septa varied from 3 to 7. The length of the beak was shorter than the length of the body of the conidia and ranged from 1.22 up to 12.30 μm. The ratio of length to width of conidia varied from 2.29 to 2.43.

1. **Introduction**

Carrot [*Daucus carota* L. subsp. *ativus* (Hoffm.) Arcang.] is one of the most important vegetable, which is traditionally used in human nutrition around the world as a useful and healthy vegetable rich in vitamins and mineral salts. Numerous pathogenic fungi threaten the cultivation and production of plants from the family Apiaceae Lindl., and fungi from the genus *Alternaria Ness* are of special importance among them.

Determining the pathogenic, morphological, rearing and molecular characteristics of these carrot pathogens is of essential importance for precise identification, characterization, determination of

population structure, determination of introduction routes and other numerous aspects of their phylogeography and epidemiology.

The study of the morphological characteristics of *Alternaria spp*. isolated from carrots was carried out based on the study of the macroscopic and microscopic characteristics of selected monosporial isolates of these fungi according to the criteria of [2].

2. Material and methods

During the three-year period (2014-2016), the material needed for the study was collected from a large number of carrot production plots from a large number of localities from the territory of Bosnia and Herzegovina, as well as several localities from the territory of Serbia, i.e. a large number of samples of different diseased parts of carrot plants on which characteristic symptoms of diseases caused by species of the genus *Alternaria* were manifested. All collected samples were delivered in paper bags to the Phytopathological Laboratory of the Agricultural Institute of the Republic of Srpska, Banja Luka, where they were washed under running water and then surface disinfected in a 3% solution of sodium hypochlorite (NaOCl) for 30 seconds, after which they were dried on filter paper and thus prepared for further work. Isolation of *Alternaria* fungi from the collected samples of diseased carrot plants was performed according to the standard phytopathological procedure [1] by aseptically placing small fragments, taken from the junction of healthy and diseased tissue of diseased carrot plant parts, on a potato-dextrose agar in a Petri dish. After five days of development in a thermostat, at a temperature of 25 °C, fungal colonies developed around the seeded fragments, from the edges of which parts of the mycelium were carefully cut, together with a thin layer of the agar, which were then transferred to test tubes with a potato-dextrose agar slant. In this way, a large number of pure cultures of *Alternaria spp*. was formed.

Monosporial isolates that developed from single conidia were then sown into test tubes with the potato-dextrose agar slant, in which way a collection of pure cultures of monosporous *Alternaria spp*. isolates was formed, which were used in further research. For these researches, selected isolates were used based on preliminary morphological and molecular identifications, namely: Isolates of group A consisting of isolates FM-15 and BM-2, which in terms of their morphological characteristics showed the most similarities with isolate CLA-108, which was the previously identified standard for the species *A. dauci*, and isolates of the group B consisting of isolates IM-14 and Mr-114, which in terms of their morphological characteristics showed the most similarities with isolate Aa-82, which was the previously identified standard for the species *A. alternata*.

Testing macroscopic characteristics included a visual inspection and description of the features and characteristics of the colonies, as well as the measurement of the growth of fungi colonies grown on a potato-dextrose agar at 25 °C.

Microscopic morphological features of the six studied isolates of *Alternaria sp*. were tested by microscoping native, temporary preparations or by examining pure fungi cultures directly (*in situ*) in Petri dishes. Temporary microscopic preparations were made from seven-day-old monospore fungi cultures grown on a potato-dextrose agar. As a carrier in temporary microscopic preparations, a drop of tap water was used in which a fragment of a colony was applied, caught with a spear needle from pure cultures of tested isolates of *Alternaria spp*. The material thus applied was then covered with a glass coverslip and directly observed under an Olympus CX 41 optical microscope at magnifications of 40× to 400×.

Among the morphological features, catenulation or Conidia arranged in chains and the spatial arrangement of the formed slow-bearing formations were tested. Catenulation was tested by direct microscoping of formed colonies. Among other characteristics, the dimensions (length and width) of the conidia, as well as the number of septa and the length of the beak, were tested. All dimensions were measured on randomly selected, fully formed and mature conidia, which were of the appropriate colour, as recommended by [3]. The average calculated for at least 100 repeated measurements was used to determine the length and width of the conidia, as well as their relationship.

3. Work results with discussion

The morphology or phenotype of the tested isolates of *Alternaria spp*., isolated from carrots grown in Bosnia and Herzegovina and Serbia, were determined based on a visual description of the macroscopic characteristics of pure cultures (colonies), microscopic characteristics of individual structures and biometric values of colony diameters and conidia dimensions.

Macroscopic characteristics. Study of important macroscopic morphological features of six selected isolates of *Alternaria sp.* originating from carrots, showed that they can be grouped into two groups according to their most important characteristics, namely group A and group B (Table 1).

Group A. This group consists of isolates FM-15 and BM-2, which, according to their morphological characteristics, showed the most similarities with isolate CLA-108, which was previously identified as the standard for the species *A. dauci*. These isolates formed whitish-gray to dark gray colonies on the potato-dextrose agar, which grew quickly (but still somewhat slower than the representatives of group B) and without stopping, filling the Petri dishes in about 10-12 days. The edges of the colony are straight or slightly wavy and lighter in colour. All tested isolates secreted pigment into the agar and stained it pinkish-red (Fig. 1a). No crystal formation was observed in the agar (Table 1).

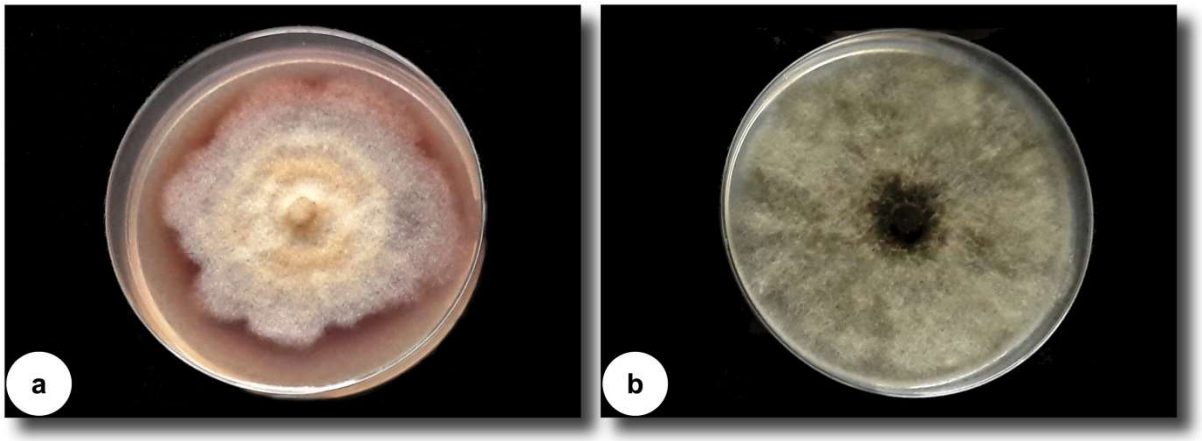

Figure 1. *Alternaria spp*. Colony features on potato-dextrose agar: a) isolate CLA-108 representative of the group A; b) isolate IM-14 representative of group B

Group B. This group consists of isolates IM-14 and Mr-114, which in terms of their morphological characteristics showed the most similarities with isolate Aa-82, which was the previously identified standard for the species *A. alternata*. These isolates on the potato-dextrose agar grew rapidly (slightly faster than the representatives of group A) and without stopping, filling the Petri dish in 7-10 days. They formed dark gray to olive gray colonies (Figure 1b), with a straight to slightly wavy edge, the youngest part of which was usually white. These isolates did not secrete pigments or stain the agar, nor did they form crystals in the agar (Table 1).

Table 1. Overview of the macroscopic characteristics of selected isolates of *Alternaria spp.*

***Isolates of Alternaria* spp.**	**Macroscopic characteristics**				
	Types of growth	**Colony colour**	**Colony Edge Features**	**Pigments present**	**Crystal formation**
Group A					
CLA-108 (*A. dauci*) **FM-15** **BM-2**	The growth is somewhat slower and without stopping	Whitish-gray and dark gray	Straight, slightly wavy, white, about 2 mm wide	Colours agar in pink	–

Group B					
Aa-82 (*A. alternata*) **IM-14** **Mr-114**	The growth is fast and without stopping	Medium to dark gray	Straight, white, about 2 mm wide	No pigment	–

Microscopic characteristics of selected isolates of *Alternaria spp*. Group A. Microscopic examination of isolates from group A (FM-15 and BM-2) *in situ* revealed that they form single, upright conidia (Figure 2a), in the form of an elongated ellipse (Figure 2b), which are sometimes smooth, but mostly ornamented and which are microscopically most similar to isolate CLA-108, which was used as a determined standard for the species *A. dauci*. The conidia of these isolates have a very characteristic long conical bright beak (Figure 1c), which is 1 to 3 times longer than the conidial body (Figure 1d) and which gradually narrows and sometimes forks in one place. The number of septa varies from 5 to 13. The average dimensions of the conidia of the examined isolates are 69.59–71.30 x 19.77–20.43 µm. The length-to-width ratio varies from 3.45 (CLA-108) to 3.57 (FM-15), while the beak length varies from 67.65 to 388.35 µm (Table 2).

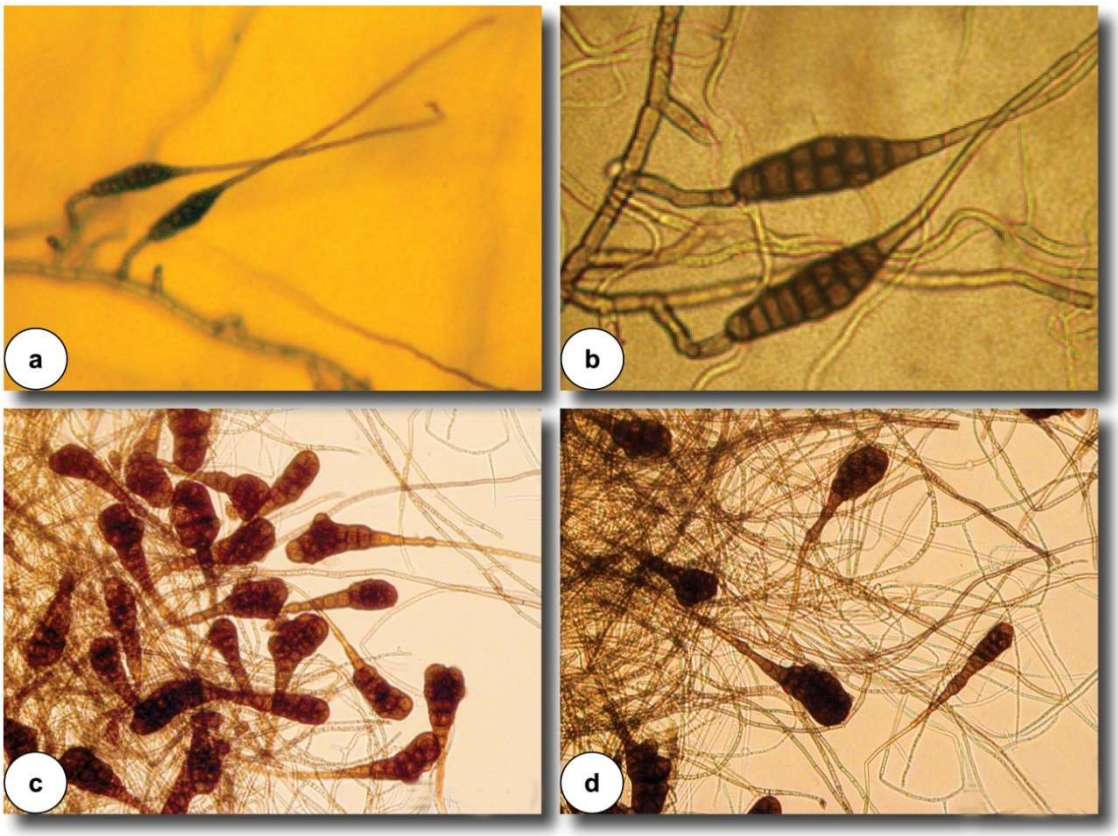

Figure 2. a) Microscopic image of formed conidia on conidiophores of isolate CLA-108 (reference isolate *A. dauci*) *in situ*; b) features of conidia formed on conidiophores of isolate FM-15; c) features of conidia of isolate BM-2; d) conidia of isolate CLA-108.

Group B. Microscopic examination of the isolates from group B (IM-14 and Mr-114) *in situ* revealed that they form conidia whose catenulation is in the form of long branched strings (Figure 3a,b), which are most similar to isolate Aa -82, in terms of microscopic characteristics and was used as a determined standard for the species *A. alternata*. Conidia are of different shapes, regularly ellipsoid (Figure 3c), round or elongated

with a short conical beak or without a beak (Figure 3d). The average size of the conidia of all three isolates was 15.17–39.57 x 7.45–14.90 µm, with 3–7 septa (Table 2). The length of the beak is shorter than the length of the body of the conidia and ranged from 1.22 to 12.30 µm. The length-to-width ratio of conidia varied from 2.29 (IM-14) to 2.43 (Aa-82) (Table 2).

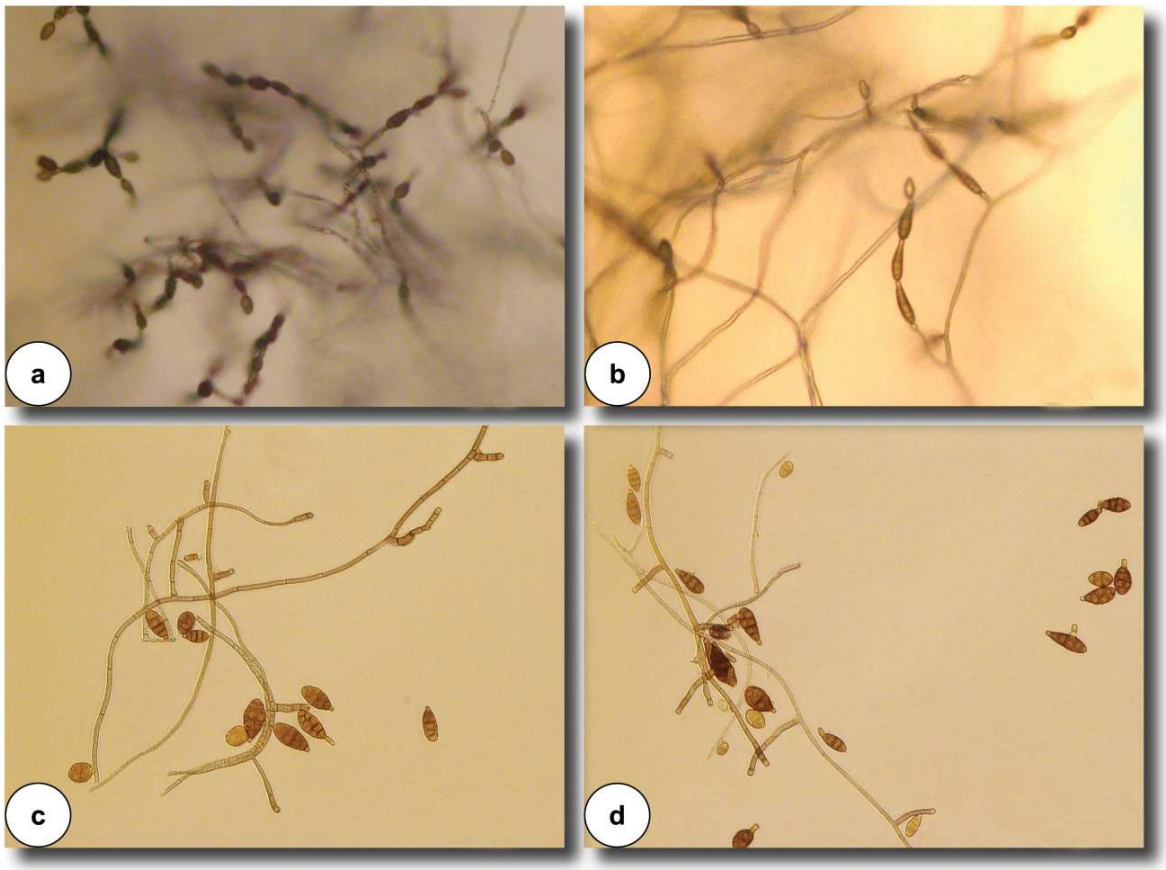

Figure 3. a) Microscopic image of formed chains of conidia on conidiophores of isolate Aa-82 (reference isolate *A. alternata*) *in situ*; b) features of chains of conidia of isolate Mr-114 formed on conidiophores *in situ*; c) features of conidia of isolate IM-14; d) conidia of isolate Aa-82.

Table 2. Review of biometric values of length and width of conidia and their interrelationship, beak length, number of septa, as well as method of conidia formation

Isolate of *Alternaria* spp.	Length of conidia (µm) min.-(average)-max	Width of conidia (µm) min.-(average)-max	Length/ width ratio	Beak length (µm)	No. of septa	Method of conidia formation
Group A						
CLA-108	50,17-(69,59)-86,73	14,10-(20,17)-26,20	3,45	75,25-350,80	5-12	Single
FM-15	50,70-(70,58)-85,25	14,75-(19,77)-25,65	3,57	67,65-373,40	5-13	Single
BM-2	51,10-(71,30)-87,30	15,05-(20,43)-27,14	3,49	72,80-388,35	5-12	Single
Group B						
Aa-82	15,17-(26,56)-36,73	7,70-(10,93)-14,90	2,43	1,22-10,40	3-7	In chains
Mr-114	15,27-(25,29)-35,95	7,53-(10,67)-14,27	2,37	1,35-12,30	3-7	In chains
IM-14	16,07-(23,90)-39,57	7,45-(10,44)-13,95	2,29	1,30-11,55	3-7	In chains

4. Conclusions

By studying the morphological characteristics of the selected isolates, it was determined that the group A isolates showed the most similarities with the CLA-108 isolate, which was previously identified as the standard for the A. dauci species.

These isolates secreted a pigment in the agar and coloured it pinkish-reddish, and in situ formed single conidia in the form of an elongated ellipse, which have a very characteristic long pointed bright beak, which gradually narrows and sometimes forks in one place.The average dimensions of the conidia of the tested isolates were 69.59–71.30 x 19.77–20.43 μm, while the number of septa varied from 5 to 13. The length of the beak was 1 to 3 times bigger than the body of the conidia and ranged from 67 .65 to 388.35 μm. The length-to-width ratio of conidia varied from 3.45 to 3.57.

In contrast to them, group B isolates showed the most similarities with isolate Aa-82, which was the previously identified standard for the *A. alternata* species. These isolates did not secrete pigments or stain the agar, and *in situ* formed conidia in the form of long branched strings, which are of different shapes, regularly ellipsoidal, round or elongated with a short conical beak or without a beak.

The average dimensions of the conidia of all three isolates were 15.17–39.57 x 7.45–14.90 μm, while the number of septa varied from 3 to 7. The length of the beak was shorter than the length of the body of the conidia and ranged from 1.22 up to 12.30 μm. The length-to-width ratio of conidia varied from 2.29 to 2.43.

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Suitability of land for cultivation of apple (*Malus domestica*) in the area of Una-sana canton

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Abstract: The consequences of improper land management are long-term, incomprehensible for agricultural production, and reflected through the loss of land, reduced yields, soil erosion, etc. In order to determine the optimal role or suitability of the land for apple cultivation within the Una-sana canton, a survey was conducted according to the FAO method of AEZ (FAO, 1976), and based on the obtained results, an assessment of the suitability of the land for apple cultivation was carried out. After research and sublimation of all the results it was confirmed that a significant land portion of the total *(415.546,44 ha)* agricultural land within the Una-sana canton are suitable for fruit production marked from S2 to N suitability class. It is evident that preexisting conditions for apple production within the municipality do exist. With the implementation of the necessary measures of soil / land regulation, education of agricultural producers, and mindfulness of constraint factors hindering intensive production such as: terrain slope, depth, rockiness and soil response; a progress in production can be made.

1. Introduction

The agricultural land of the Una-Sana Canton represents a natural resource that is of strategic importance for the further economic development of this region. The total area of the Canton is 415,546.44 ha, which is 15.79% of the total area of the Federation of Bosnia and Herzegovina. There are 194,821 ha of agricultural land, 202,876 ha of forest land, and the rest is a barren land. From the data listed above, it can be concluded that the areas of agricultural land are approximately equal to the forest areas, and with favorable climatic conditions, they represent a good basis for agricultural production. In the part of the land, which is plowed on regular basis, there is no data regarding the land suitability for growing apples, as well as other agricultural crops. By applying the FAO methodology of agro-ecological zoning, an assessment of the land suitability of the Una-Sana Canton for apple cultivation was made and three classes of land suitability for apple cultivation were determined in the research area, which are presented for viewing through a map in the chapter "Research Results".

2. Material and Methods

The soil/land as the subject of suitability assessment encompasses a wide array of different suitability factors required for the assessment of the intended use of space (FAO, 1976 and Vidaček et. al. (n.d.). The applied model of agro-ecological zoning is the methodology used for assessing the suitability of soil for agricultural production. AEZ system is used in order to determine the specific limitations for crop cultivation in certain climate, soil and terrain conditions.

A detailed description of the AEZ method used in this research can be found in FAO Guidelines on Agro-ecological Zoning (FAO Soils Bulletin 73, Rome, 1996). The data on boundaries of agrozones was obtained from The Federal Agro-Pedological Institute, and the data on climate were obtained from the Federal Hydrometeorological Institute. Reconciliation of specific requirements of crops, defined by LUT, with the parameters of soil texture, reaction, contents of organic carbon and soil depth, renders the degrees of soil suitability for cultivation of certain crops. The interaction of these parameters results in the final form for land utilization planning.

Table 1. The levels of suitability of soil/land per parameters (Biancalani et al., 2004).

Suitability parameters	Classification	Limit values of parameters
Soil depth	S1	100-150 cm
	S2	70-100 cm
	S3	50-70 cm
	S4	30-50 cm
	N	<20 cm
Soil reaction	S1	6.5 - 7
	S2	5.5 – 6.5 7 – 7.2
	S3	5 – 5.5 7.2 – 7.5
	S4	7.5 – 7.9
	N	<5 >7.9
Soil texture	S1	I, PrI, PGI, PI, PrGI
	S2	PrG, GI
	S3	PG, PI
	S4	Pr, P
	N	G
Organic carbon	S1	20 - 50 g/kg
	S2	50 - 60 g/kg
	S3	10 - 20 g/kg
	S4	60 - 100 g/kg
	N	<10 g/kg >100 g/kg

Table 2. Soil/land suitability classes (Biancalani et al., 2004).

Classification	Suitability class	% suitability
S1	Highly suitable	> 80
S2	Suitable	60-80
S3	Moderately suitable	40-60
S4	Limitedly suitable	20-40
N	Unsuitable	< 20

The Levels of Suitability of Specific Soil Parameters for Successful Cultivation of Corn (Zea mays)

Table 3. The Degree of Suitability of Specific Parameters for corn (Source: Biancalani et al., 2004).

Parameters	S1	S2	S3	N
pH	6,5-7,2	5,5-6,5 7,2-7,5	4,5-5,5 7,5-8,0	<4,5; >8,0
Depth in cm	>100	50-100	20-50	<20
Texture	I, PrI, PGI, PI, PrGI	PrG, GI,	Pr, PG, PI	G
Total C	>20	20 – 10	<10	-

3. Results and Discussion

In order to describe the climatic characteristics of the Una-Sana Canton, the data was provided by the Meteorological Station Bihać, which is located at 246 m. The data was gathered during the period of observation from 1961 to 1990 and the period from 1999 to 2009.

According to the data of the Meteorological Station Bihać, the length of the vegetation period within the area of the Una-Sana Canton is 264 days for cryophilic plants (+5 ºC), and 204 days for thermophilic plants (+10 ºC) (Šarić et al., 2010).

Table 4. Average monthly and annual air temperature for the Bihać area, in the periods from 1961 to 1990 and from 1999 to 2009, measured in °C (Source: Federal Hydrometeorological Institute).

Period	Months												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1961-1990	0,3	2,3	6,1	10,7	15,1	18,3	20,1	19,3	15,9	11,3	6,3	1,7	10,6
1999-2009	1,4	3,1	7,3	11,5	16,7	20,0	21,5	20,9	15,6	12,4	7,5	2,9	11,7

Looking at the data of average monthly temperature, it can be observed that the average temperature values are higher during the observation period from 1999 to 2009 in all months except September, during which a miniscule drop in the average monthly air temperature of 0.3 ºC was recorded.

The consequence of the increase in the sum of temperatures at the monthly level was also reflected in the increase in the average annual temperature.

In the first period, from 1961 to 1990, the average annual air temperature was 10.6 ºC, while in the period from 1999 to 2009, the average annual air temperature was measured at 11.7 ºC, which is an increase of 1.1 ºC.

Global warming certainly contributes to an increase in the average temperature, and if the same continues, higher average air temperatures can certainly be expected.

Estimates of some studies are that the warming in the temperate latitudes of the northern hemisphere will increase and be greater than the world average and will range between 0.8 ºC and 1.0 ºC for every 10 years. (Komljenović et al., 2014; Žurovec, et al., 2015).

Table 5. Average monthly and annual precipitation for the area of Bihać, in the periods from 1961 to 1990 and from 1999 to 2009 in mm (Source: Federal Hydrometeorological Institute).

Period	Months												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1961-1990	86	91	99	115	116	109	106	109	108	110	146	114	1.309
1999-2009	103	96	106	120	112	83	87	97	139	116	132	149	1.342

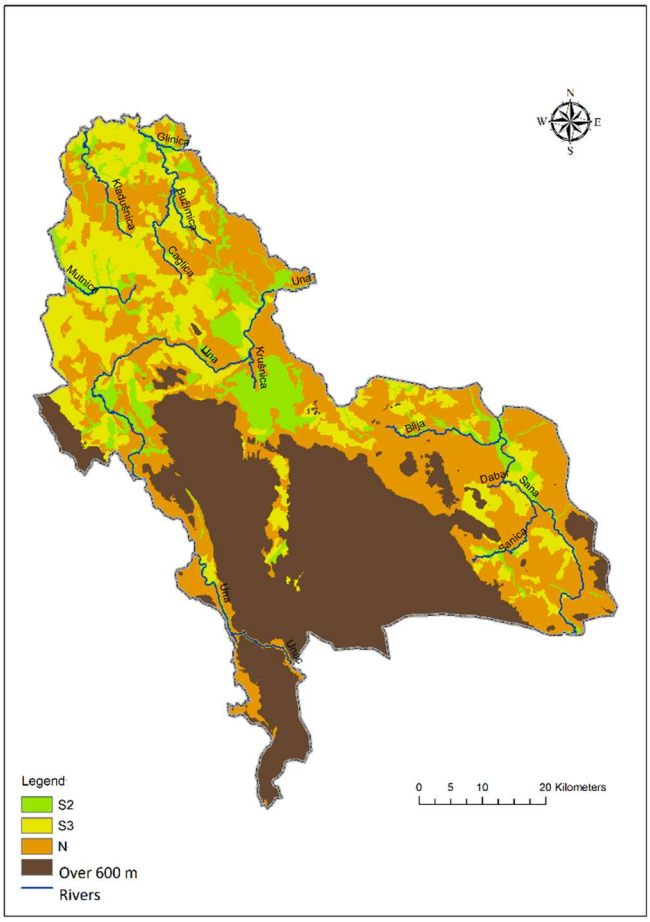

Figure 1. Map of the overall suitability of USK land for apple cultivation.

If we look at the ratio of atmospheric precipitation by season, it can be seen that autumn is the season most abundant with precipitation, something which was observed during both time periods. More than one third of annual precipitation falls in autumn. What is characteristic of the time period from 1961 to 1990 is that more atmospheric precipitation fell in the summer than in the winter. If we compare the total annual amount of precipitation for the period from 1961 to 1990 - 1,309 mm with the amount from the period from 1999 to 2009 - 1,342 mm, we have to conclude that there was an increase in the amount of precipitation by 33 mm.

The number of apple trees in the Una-Sana Canton was 153,567. Data collected place the apple fruit in the second place among fruit species in the Canton area. Most often, these are semi-intensive plantings are to be found on larger or smaller areas and homesteads. In accordance with the obtained research results, a map of the overall suitability of land in the Una-Sana Canton for apple cultivation was prepared and divided into three classes: S2 and S3 and N class of unsuitable land.

- The S2 class of land convenience in the territory of the Canton has areas along river courses, i.e., lower altitudes.
- The largest areas of class S2 are located in the municipality of Bosanska Krupa along the Krušnica river, then along the left bank of the river Una. They are most often represented by the fluvisol soil type. Also, significant areas of S2 convenience class are located on the stretch from Bihać towards town Bosanski Petrovac in the village of Ripač, upstream along the river Una.
- The S3 convenience class takes up a larger area of the western part of the Canton in the municipalities of Cazin, Velika Kladuša and Bužim, and the largest areas of land occupied by this class belong to the municipality of Cazin.
- A smaller part of the S3 class is located in the municipalities of Sanski Most and Ključ.

Most of the area of the municipalities of Sanski Most, Ključ, Bosanski Petrovac and the peripheral parts of the municipality of Bosanska Krupa are areas marked with the N class of convenience (unsuitable) for apple growing.
In addition to the mentioned parameters, great attention must be paid to cultivation itself, meaning, techniques must be adapted to the type of soil, crop, topography, risk of erosion and climate, in order to maintain and improve soil fertility (Kurtović et al., 2008).

4. Conclusion

The Una-Sana Canton is located in the northwest of Bosnia and Herzegovina, a geographical area which is 415,546.44 ha. Administratively, it consists of eight municipalities.

The average annual air temperature for the area of Una-Sana Canton in the period from 1961 to 1990 was 10.6 ºC, while in the period from 1999 to 2009, the average annual air temperature was 11.7 ºC, which is an increase of 1. 1ºC.

The average amount of annual precipitation for this area, in the period from 1961 to 1990, is 1,309 mm, and for the period from 1999 to 2009, 1,342 mm. A comparison of the results leads to the conclusion that there was an increase in the amount of precipitation by 33 mm.

The suitability of land for apple cultivation in the area of USK is defined through three classes of suitability. S2 convenience class is located along river courses, areas with lower altitudes, the Bosanska Krupa municipality area along the Krušnica river, then the left bank of the Una. They are most often represented by the fluvisol soil type. Then, the areas on the stretch from Bihać towards Bosanski Petrovac in Ripač, upstream along the Una river.

The larger area of the western part of the Canton is marked with the S3 convenience class. A smaller part of the S3 class is located in the municipalities of Sanski Most and Ključ. Most of the area of the municipalities of Sanski Most, Ključ, Bosanski Petrovac and the peripheral parts of the municipality of Bosanska Krupa are areas marked with the N class of convenience (unsuitable) for apple growing.

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The potentials of Solar Power Plant construction in Una-Sana Canton

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Abstract With all its benefits, modern life as we know it requires a large amount of energy (for industry, transport, housing, etc.). Unfortunately, the production of energy from non-renewable sources (coal, natural gas, oil, nuclear energy) damages the ecosystems, causes ozone holes and leads to environmental crises and climate disasters. For this reason, many developed countries are focusing their policies and investments towards renewable sources (Sun, wind, water, biomass, etc.), that have a less harmful impact on the environment. For countries like Bosnia and Herzegovina, which has the natural and technical capability for exploitation of renewable sources, such investments can, in addition to environmental benefits, represent significant long-term growth potential. This paper provides a brief overview of renewable energy potentials in B&H, focusing on solar energy in Una-Sana Canton. It presents the development of renewable energy technologies, advantages and disadvantages of Solar Power Plants (SPP) and lists the most important SPP manufacturers. Finally, the paper covers the legal framework relevant to Una-Sana Canton and analyzes the possibilities of SPP construction in Una-Sana Canton.

1. Introduction

Generally, energy sources are divided between "renewable" and “nonrenewable” sources. Nonrenewable energy comes from sources that will run out or will not be (cannot be) replenished. Most nonrenewable energy sources are fossil fuels: coal, petroleum, and natural gas, with carbon being the main element in fossil fuels. Currently, fossil fuels produce most of society’s electric and engine power. Unfortunately, they have many negative sides. Firstly, they take hundreds of millions of years to form and when burned to produce energy, cause harmful greenhouse gas emissions, such as carbon dioxide, which means that while producing energy, they also produce almost all of our pollution. Renewable energy, on the other hand, is energy derived from natural sources that are replenished at a higher rate than they are consumed. Renewable energy sources such as wind, sun, water and biomass are plentiful and all around us. Nowadays, renewable energy is cheaper in most developed countries and generates three times more jobs than fossil fuels.[1]

Bearing in mind that Bosnia and Herzegovina has the natural and technical capability for the exploitation of renewable sources, investing in the use of renewable energy potentials can represent an opportunity to tackle the climate change and air pollution problems while having a positive impact on the overall energy stability and sustainable growth of B&H. This paper aims to provide a brief overview of renewable energy potentials in B&H, focusing on solar energy potentials in Una-Sana Canton. The

main goal of the paper is to explore the existing solar technologies, advantages and disadvantages of SPP, provide the technical and natural requirements for the construction of SPP and respond to the question if there are possibilities of SPP construction in Una-Sana Canton.

1.1. Solar energy

Having in mind that sunlight is crucial for the survival of both plants and animals as well as for the sustainability of the natural cycle of rivers and oceans, the Sun is commonly known as the source of life. In addition, the Sun is an unlimited and renewable energy resource. The sun offers free and clean energy in abundance. Depending on the several different conditions on a specific location (season, latitude, weather, climate conditions, atmospheric pollution etc.), solar energy as a resource is available to all people to a greater or lesser extent. Solar energy isn't depleted when used. Instead, the sun naturally regenerates, or renews, its photovoltaic energy at a rate exponentially faster than humans can harvest that energy. The power of the Sun received by the Earth is about 1.8x1011 MW, which is far beyond all modern society's demands for energy. Solar energy has existed as long as the sun—about five billion years. While people have not been around that long, they have been using solar energy in a variety of ways for thousands of years. By using solar energy, the need for fossil fuels is reduced and the environmental pollution caused by their combustion is also reduced. Solar energy does not produce greenhouse gases that cause global warming and radioactive waste. Quite the opposite, solar energy reduces carbon emissions and greenhouse gases. Within the first few years of operating a solar energy system (which emits around 50 grams of carbon dioxide per kilowatt-hour), the solar panel's carbon footprint is about 20 times less than the carbon emitted by coal-powered electricity sources. In addition, solar energy doesn't contaminate water, soil and other environmental landscapes when used. [2]

Solar energy is one of the world's fastest-growing energy technologies. Solar technologies can deliver heat, cooling, natural lighting, electricity, and fuels for a host of applications and are proven to be one most attractive option for electrical energy production in grid-connected and distributed modes.

2. Photovoltaic systems (PV)

Photovoltaic systems are systems that receive solar energy and convert it into electricity. They convert solar radiation, made up of light, heat, and ultraviolet radiation, into electricity suitable for domestic or industrial use. [3]

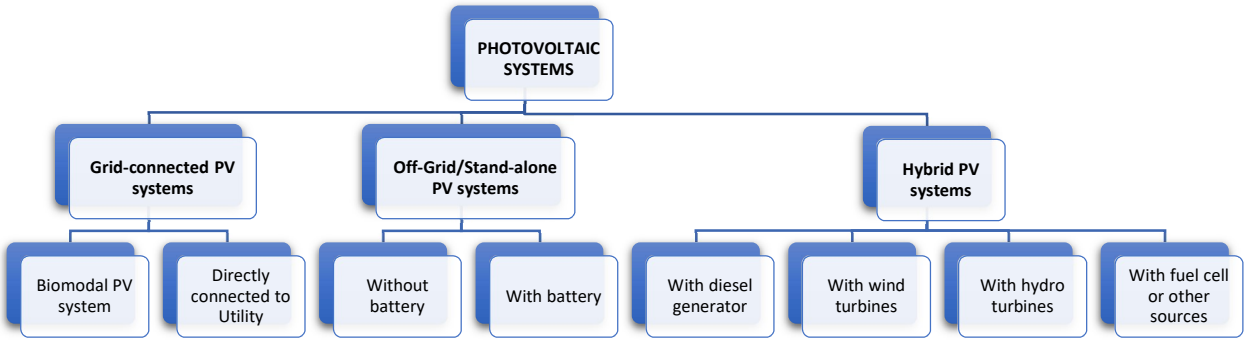

Figure 1. PV System types and their Components [3].

As Figure 1 shows, PV systems can be divided into three main types: Grid-connected PV systems, Off-grid (Stand-alone) PV systems and Hybrid PV systems. Off-grid (Stand-alone) PV systems work without the utility grid and are generally an effective solution in cases where there is no possibility for the usage of grid-connected solar photovoltaic systems due to geographical restrictions or high costs. These systems include, in most cases a battery or some kind of additional hybrid source, to ensure the supply of electric energy also during the night or when the level of solar irradiation is insufficient or

absent. Grid-connected PV systems use the basic grid-tied inverter which does not require a battery and accumulators to operate because the public power grid has the role of electricity storage. Generally, Grid-connected PV systems are integrated with conventional industry/residential electric systems which can be used in alternation or in combination with the electricity grid in order to meet the energy requirements of the end user. [4]

As furtherly seen in Figure 1, Not all PV systems are alike in terms of system components, size and type of application. For example, in cases of solar water pumping for rural application without access to an electricity grid, the components are slightly different from rooftop solar systems for housing applications, where a grid already exists. However, for major components of a solar power plant are the panels, inverter(s), racking and solar battery storage unit(s).

2.1. Solar panels

The most important part in this system are the solar panels (modules) which, combined with an inverter and other electrical/mechanical hardware absorb the sunlight and generate electricity. The solar panel consists of multiple solar cells connected in series and parallel to each other in order to make its total output power as high as possible. When the sun's rays strike directly at the solar panels, the electrons contained in the more external layers of the photovoltaic cells absorb the radiation and generate direct current electricity. These cells are connected in series and then integrated into a single module, forming photovoltaic panels, as shown on Figure 2. As the solar panels are connected in parallel, forming strings coupled to a current inverter, the direct current coming from the photovoltaic cells is transformed into alternating energy. Photovoltaic cell efficiency, based on silicon type and cell design, and total panel efficiency, depending on cell arrangement, configuration, and panel size, are the two primary determinants of solar panel efficiency. By creating a bigger surface area that absorbs sunlight, increasing the panel size can also boost efficiency. [5]

Nowadays, solar modules are made in different shapes and with different numbers of solar cells.

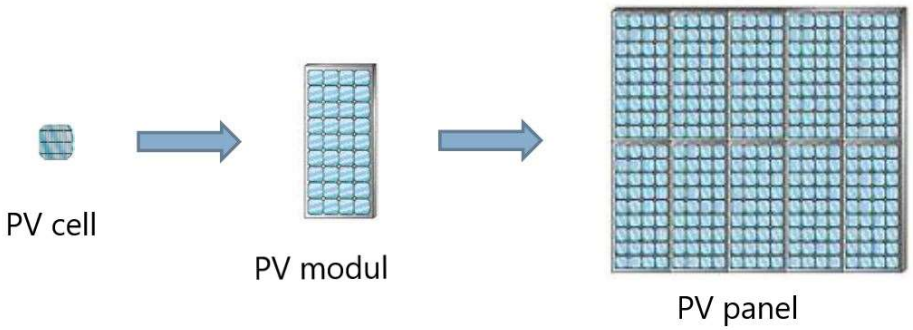

Figure 2. Construction of PV panels from PV cells [3].

Most commonly, solar power plants use panels consisting of photovoltaic solar cells made of silicon (Polycrystalline/Monocrystalline solar panels) or other materials which have photovoltaic properties (Amorphous solar panels). The most used types of solar modules are the Polycrystalline solar module and Monocrystalline solar modules, as shown in Figure 2.

Figure 3. Polycrystalline and monocrystalline solar panels [5].

Table 1 shows an overview of how the differences between these panels might impact solar panel systems.

Table 1. Monocrystalline and polycrystalline panels, most important differences.

Factor	Monocrystalline panels	Polycrystalline panels
Silicone Arrangement	One pure silicon crystal	Many silicon fragments melded together
Lifespan	25-40 years	20-35 years
Cost	More expensive	Less expensive
Efficiency	More efficient, 15% to 23%	Less efficient, 13% to 16%
Temperature coefficient	Lower temperature coefficient, more efficient in heat	Higher temperature coefficient, less efficient in heat
Panel appearance	Black	Blue

As seen in the Table 1, the Monocrystalline and Polycrystalline panels differ across various factors, including overall cost, appearance and efficiency. The Monocrystalline solar panels are made of a highly pure form of silicon and offer the highest efficiency rates currently available on the market, between 15% and 23%. The main benefits of these panels are the fact that they generate high power, are relatively long-lasting and have a size which is suitable for homes. Bearing in mind that Polycrystalline solar panels are made from raw silicon, due to their blue hue, they are easily identifiable. They are cheaper than the first type of panels but are less efficient (only around 15%) although they generate the same power. In addition, they take up more space and are more sensitive to high-temperature exposure.

In addition to the two most used panels, on the market, there are also Amorphous solar panels that use materials such as amorphous silicon, cadmium telluride, or gallium with photovoltaic properties. For this reason, these panels are flexible and lightweight. However, they are not as efficient as conventional photovoltaic panels but are more economical, which is why they're commonly used in large installations (industries, public facilities). In addition to this, on the market, there are also Hybrid solar panels, which are still being developed and under research. This type of solar panel allows a combination of both photovoltaic cells and thermal collectors into a single system. These systems can also be combined with other renewable energy sources to obtain a greater energy contribution. One of

the main benefits of Hybrid solar panels is the fact that they are capable of transforming sunlight into electricity and heat, increasing the performance of photovoltaic cells by up to 15%. [5]

In addition, the industry continues to innovate to achieve increasingly efficient energy solutions, inter alia: *concentrator photovoltaics, bifacial panels, spherical cells* and *heterojunction solar cells*.

2.2. Solar panel manufacturers

Over the years, with rising interest towards achieving sustainable and cheap energy, the solar panel market has consistently grown. Nowadays, across the world, there are many companies that produce high-quality solar panels and equipment for solar power plants. Amongst them, these companies are recognized as the highest-ranking solar panel manufacturers: Kioto Solar (Austria), Solarwatt (Germany), CW Enerji (Turkey) and Hyundai Energy Solutions Co., Ltd (China).

Table 2. Comparison of characteristics of selected Solar Panels.

Solar Panel				
Serial Number	**CWT310-335-60PM**	**Power-60 KPV ME NEC 300-310Wp mono**	**HiA-S300-315HG**	**Vision 60M style (black edition)**
Company	**CW Enerji**	**KIOTO Solar**	**Hyundai Energy Solutions Co., Ltd**	**Solarwatt GmbH**
Product Warranty	12 Years	Warranty 12 Years	10 Years	30 Years
Power Warranty	12 Years of 90% Output Power, 30 Years of 80% Output Power	--	25 Years of 80% Output Power	30 Years of 87% Output Power
Electrical Data at STC				
Maximum Power (Pmax)	310 ~ 335 Wp	300 ~ 310 Wp	300 ~ 315 Wp	320 ~ 325 Wp
Voltage at Maximum Power (Vmpp)	33.04 ~ 34.4 V	32.28 ~ 32.91 V	32.15 ~ 32.79 V	33.6 ~ 33.9 V
Current at Maximum Power (Impp)	9.4 ~ 9.75 A	9.29 ~ 9.42 A	9.33 ~ 9.6 A	9.52 ~ 9.6 A

Open Circuit Voltage (Voc)	40.15 ~ 41.56 V	38.23 ~ 39.28 V	39.25 ~ 39.74 V	40.2 ~ 40.4 V
Short Circuit Current (Isc)	10.03 ~ 10.38 A	9.69 ~ 9.85 A	9.77 ~ 10.04 A	10.2 ~ 10.31 A
Panel Efficiency	18.49 ~ 19.96 %	18.15 ~ 18.76 %	18.1 ~ 19 %	18.8 ~ 19.1 %
Power Tolerance (Positive)	+1.5 %	+1.5 %	+3 %	+5 %
Thermal Ratings				
Operating Temperature Range	-40~85 °C	-40~85 °C	-40~85 °C	-40~85 °C
Temperature Coefficient of Pmax	-0.36 %/°C	-0.37 %/°C	-0.417 %/°C	-0.39 %/°C
Temperature Coefficient of Voc	-0.27 %/°C	--	-0.306 %/°C	-0.28 %/°C
Temperature Coefficient of ISC	0.040 %/°C	--	0.046 %/°C	0.04 %/°C
Maximum System Voltage		1000 V	1500 V	1000 V
Series Fuse Rating	20 A	15 A	20	--
Material Data				
Panel Dimension (H/W/D)	1668x1007x35 mm	1666x992x40 mm	1675x992x35 mm	1700x1000x35 mm
Weight	19 kg	19.5 kg	18.5 kg	22 kg
Cell Type	PERC	PERC	Monocrystalline	PERC
Cell Size	158.75×158.75 mm	156×156 mm	--	--
Cell Number	60	--	120	60
Glass Type	Anti-reflection Coating	Anti-reflection Coating	Anti-reflection Coating	Anti-reflection Coating, Tempered

3. Advantages and disadvantages of SPP and solar energy

In addition to the above-stated environmental reasons which derive from the fact that solar power is a renewable energy source, there are many other advantages of solar energy and SPPs. Firstly, after the installation of the solar panels, the electricity bills will be significantly reduced. The savings depend on

the size of the solar system and the use of this system. With power prices on the rise, it is possible to save a considerable amount on monthly power bills by switching to solar. In addition to this, solar energy can be applied for different goals and these systems don't usually need much maintenance. Finally, except for the first initial cost, then there is little spending on maintenance throughout the period to come. Once installed, a solar system requires little maintenance as long as it remains unaffected by environmental factors. If panels are kept clean and free of debris, they should continue to function without any additional action by the consumer for many years. The main disadvantage of solar energy is the initial cost. Despite decreases in the cost of solar technology over the past ten years, a complete solar installation still requires significant investment. The costs of solar panels, batteries, wiring, inverter and the installation itself make the initial purchase of solar system quite high. However, with the improvement of technology, these costs are expected to decrease more in the next few years. [4]

Generally, one can state that solar power systems are relatively weather dependent. Although they still generate electricity on cloudy days, solar power systems produce the most energy when in sunny days. In addition, if not used right away, the energy has to be stored in large batteries. Furthermore, for the purposes of producing more energy, it is required to have more solar panels, which implies the use of more space/land. Depending on the number of solar panels needed, finding enough space with adequate exposure can be difficult, especially in less-spacious residential areas.

4. Legal framework related to solar power plants in Una-Sana Canton

Due to Bosnia Herzegovina's constitutional framework, the entity ministries are in charge of developing legislation related to energy, and therefore renewable energy sources. The competencies between the state and the entities (Federation of BiH and Republika Srpska, and Brčko District) in the energy sector are divided, making the political and legislative framework for RES relatively complicated. As the state level is responsible for international cooperation, coordination with the entities and transmission of electricity, the entity levels have real competencies in the field of energy, namely: production, distribution, and supply. The regulation of the legislative framework in the field of RES in B&H is the result, among other things, of the obligations pursuant to international agreements which B&H signed as the Energy Community Treaty member. However, they are not amended in accordance with the requirements and initiatives of Energy Community Treaty.

The following Laws are relevant for the RES, thus solar power plants construction:

- Law on Electricity (Official Gazette of Bosnia and Herzegovina No. 66/13)
- Law on Amendments to the Law on Electricity in the Federation of Bosnia and Herzegovina ("Official Gazette of the Federation of Bosnia and Herzegovina" No. 61/22)
- Law on the Use of Renewable Energy Sources and Effective Cogeneration (Official Gazette of the Federation of Bosnia and Herzegovina, No. 70/13)
- Law on Amendments to the Law on the Use of Renewable Energy Sources and Effective Cogeneration (Official Gazette of the Federation of Bosnia and Herzegovina, No. 5/14).
- Law on concessions of the Federation of BiH (Official Gazette of the Federation of Bosnia and Herzegovina, No. 40/2002 and 61/2006)
- Law on Concessions (Official Gazette of the Una-Sana Canton; No. 10/03, 7/09, 19/13, 9/17 and 18/19)

In addition to this, the Assembly of the Una-Sana Canton adopted the new Law on Concessions in 2022, which prescribes new legal solutions compared to the previous ones that regulate concession rights in the field of renewable energy sources (RES) in a better way.

5. The potentials of Solar Power Plant construction in Una-Sana Canton

The Una-Sana Canton is in the northwestern part of Bosnia and Herzegovina. With a total area is 4,125 km2, USC is the second-largest canton in FBiH. The USK covers 15.8% of the FBiH territory, which is 8.05% of the total territory of Bosnia and Herzegovina. The administrative and economic center of USC is the city of Bihać, and in the USC territorial-political system, there are eight municipalities (Bihać, Bosanska Krupa, Bosanski Petrovac, Bužim, Cazin, Ključ, Sanski Most and Velika Kladuša). Una-Sana Canton is known for its natural beauty, biodiversity, and plentiful renewable energy sources. Thus, renewable energy sources are recognized in the *Una-Sana Canton Development Strategy 2021 – 2027* and are addressed in one of the strategic goals (Strategic goal 3: Sustainable management of the environment, natural and infrastructure resources), based on strategic directions and the development vision of USC. [6]

5.1. Climate characteristics of Una-Sana Canton

The USK area belongs to a moderately continental climate characterized by harsh and snowy winters and warm summers. This Canton is characteristic for its northeast and southwest winds that bring continental and Mediterranean. The average annual number of sunny hours is between 1772 and 1970, and there are an average of 206 cloudy days per year. The average annual temperature is 11.4°C. The warmest month is July with an average monthly temperature of 22°C, and the coldest is January with an average temperature of -6°C. The highest amount of precipitation occurs during autumn and spring, and the average amounts range from 1000 to 1300 l/m2. The rainiest month is November, and the driest is January. In the lower areas, the snow stays between 40 and 60 days a year, and in the mountains up to 90 days. The average annual air humidity is about 75%. The heating season in the USK area lasts from October 15 to April 15. [6]

Table 3 provides data gathered with the METEONORM software package on the number of hours of sunshine for certain localities in Bosnia and Herzegovina.

Table 3. Number of sunny hours for B&H meteorological stations [7].

Location of the meteorological station	Number of sunny days (h/year)
Neum	2600,0
Mostar	2352,5
Čitluk	2342,0
Livno	2337,0
Ivan Sedlo	1850,3
Drvar	1839,9
Bjelašnica	1823,1
Sarajevo	1794,2
Bihać	1783,9
Banja Luka	1776,2
Tuzla	1761,9
Zenica	1618,4

Furthermore, Table 4 shows the Values of the intensity of total solar radiation in Una-Sana Canton.

Table 4. Values of the intensity of total solar radiation in Una-Sana Canton (kWh/m^2 year) [7].

	horizontal surface			**vertical surface**			**sloping surface - 45°**		
	min.	average	max.	min.	average	max.	min.	average	max.
Una-Sana Canton	1087	1277	1469	818	1001	1203	1192	1456	1736

If a comparison is made with the values of total solar radiation on the horizontal surface in the countries of Central and Northern Europe, where the annual averages are 1150 and 1000 kWh/m2 year, we come to the conclusion that on average Una Sana Canton receives about 10% more solar energy compared to Central Europe, and 20% more than Northern Europe (Netherlands, Denmark, Great Britain). Particularly, Austria, which has about 30% less potential than BiH represents the world record holder in the area of thermal collectors per inhabitant. [7]

5.2. Energy infrastructure of Una-Sana Canton

USC electricity distribution facilities operate as part of the unified electric power system of BiH. The transmission and distribution of electricity to end users are performed by the Public Company Elektrodistribucija Bihać. The electricity in UNC, with a total power capacity of 8.5 MW, is provided by HPP Krušnica (0.5 MW) and HPP Una-Kostela (8 MW). The electric power infrastructure consists of an overhead transmission network and underground cables.

Some of the challenges related to the energy infrastructure, which are important for the analysis of the potential of construction of solar power plants in the Una-Sana Canton, is the fact that the existing power grid in USC is partially overloaded and inefficient, which can cause technical failures. [6]

The biggest challenge for the construction of solar power plants in the Unsa-Sana Canton is the insufficient capacity on the distribution network, for which the Elektrodistribucij" Bihać can directly issue the power consent, as shown in Table 5.

Tabel 5. Overview of the capacities of the "Elektrodistribucija Bihać" network [8].

Elektroprenos BiH Transformer-station ED Bihać Station	**Max. average customer power (kW)**	**Sum of the power of the solar plants in operation (kW)**	**Sum of power for previously issued power consents (kW)**	**Sum of the power plants of unsolved requests (kW)**	**Sum of power of all power plants (kW)**	**Remaining capacity (kW)**	**Municipality powered by the transformer station 110/x kV**
TS Bihać 1	14.090	7.052	267	6.173	13.492	597,7	Bihać
TS Bihać 2	7.658	0		9.486	9.486	0,0	Bihać
TS Bosanska Krupa	6.512	323	6.166	6.060	12.549	0,0	Bosanska Krupa
TS Bosanski Petrovac	3.821	1.200	20.296	47.964	69.460	0,0	Bihać, Bosanski Petrovac

TS Cazin 1	13.862	300	1.690	17.929	19.919	0,0	Cazin, V.Kladuša
TS Cazin 2	2.421	0	0	4.465	4.465	0,0	Cazin
TS Ključ	2.997	0	2.560	1.874	4.434	0,0	Ključ, Sanski Most
TS Sanski Most	7.548	0	1.980	7.215	9.195	0,0	Sanski most
TS Velika Kladuša	8.268	0	0	11.384	11.384	0,0	Velika Kladuša
TS Vrnograč	2.198	0	0	1.937	1.937	261,5	Bužim, Velika Kladuša
TS Bužim	3.672	0	0	6.716	6.716	0,0	B. Krupa, V. Kladuša, Bužim
TOTAL	**73.047**	**8.875**	**32.959**	**121.203**	**163.037**	**859**	

As can be seen from Table 4, there is only a limited available capacity left on the distribution network, for which "Elektrodistribucija" Bihać Station can independently issue an electric power permit. However, this does not mean that additional power plants cannot be connected to the distribution network, but such connections require the consent of Elektroprenos BiH because the produced electricity in these cases cannot be consumed within the distribution network and must be transported through the network of Elektroprenos BiH to major centers of electricity consumption. For 110/x kV transformer stations where there is no capacity to connect new production facilities, the connection depends exclusively on the capacity and technical conditions of connection provided by the company Elektroprijenos BiH.

5.3. Programs of the Federation of BiH that promote the use of renewable energy sources to produce electricity.

In light of global efforts to decarbonize the energy sector and the most recent commitments to green energy through the Paris Agreement and the Sofia Declaration, many countries worldwide have developed appropriate mechanisms to encourage the production of electricity from renewable energy sources. In the Federation of Bosnia and Herzegovina, the promotion of electricity from renewable sources is based on guaranteed tariffs. The calculation of guaranteed purchase prices is carried out by Regulatory Commission for Energy in the Federation of Bosnia and Herzegovina (FERK) on the basis of the *Rulebook on methodology on the method of determining guaranteed prices of electricity from plants for the use of renewable energy sources and efficient cogeneration* ("Official Gazette of the Federation of BiH" No. 50/14). This calculation is performed every 18 months, while the final approval of these prices prepared by FERK, on the proposal of the Federal Ministry of Energy, Mining and Industry, is given by the Government of the Federation BiH. This is calculated with respect to investment costs, capital price, operation and maintenance costs, fuel costs, and the investment return period are considered, based on which guaranteed purchase prices are obtained for all plants depending on the installed power and the primary energy source used. In addition, FERK is responsible for calculating the reference price of electricity, which represents the purchase price for plants that use renewable energy sources and whose production is not encouraged. This price is calculated in accordance with the *Rulebook on the methodology for determining the reference price of electricity* ("Official Gazette of the Federation of BiH" No. 50/14, 100/14 and 82/21) and is calculated every 18 months. The Law on the use of renewable energy sources and efficient cogeneration stipulates that all qualified producers who

acquire the status of a privileged producer have the right to sell the produced electricity at guaranteed prices during a period of 12 years. It is also defined that a qualified producer who has not acquired the status of a privileged producer, and a qualified producer whose privileged producer status has expired has the right to purchase energy at the reference price, if his production is included in the binding quotas prescribed by *Action plan of the Federation of BiH for the use of renewable energy sources* (APOEF). In addition to these benefits, the abovementioned Law also recognizes a number of other privileges that RES producers can use, such as: advantage in resolving requests for connection to the power grid, advantage in delivering electricity without reporting the daily schedule to the network operator for plants with an installed capacity of less than 150 kW, the right to a guarantee of origin and advantage in dispatching etc. According to FERK Report, during 2021, 18,667,549.68 KM was paid to privileged producers for purchased electricity from RES at guaranteed contracted prices and 64,227,058.95 KM for the reference part of the guaranteed price of purchased electricity from privileged producers and purchased electricity from qualified producers and manufacturer in trial operation. [9]

The largest number of qualified producers and producers in trial operation in 2021 were actually company who use solar power plants to produce electricity, as shown in Table 6.

Table 6. Number and total installed capacity of privileged producers, qualified producers and producers in trial operation in 2021[9].

Type of power plant	Privileged producers		Qualified producers		Producers in trial operation	
	No. of power plants	Total power (kW)	No. of power plants	Total power (kW)	No. of power plants	Total power (kW)
Solar power plants	383	33.137	-	-	94	3.387
Hydropower plants	41	40.300	26	40.300	2	2.616
Wind power plants	6	36.100	2	50.900	1	48.000

The aforementioned Report also records the increase in solar power plants built for the period from 2017 to 2021, as shown in Table 7.

Table 7. Number of solar power plants built in FBiH [9].

2017	2018	2019	2020	2021
128	*142*	*178*	*279*	*453*

While in 2017 the number of license holders for the production of electricity through solar power plants was 128, in 2021 that number increased to 453 qualified producers.

5.4. Other funding opportunities

In addition to the above, the financing of the construction of solar power plants can also be achieved through loans provided by the following financial organizations:

For a long time, the **European Investment Bank (EIB)** has opened access through domestic banks to European financial instruments (EFIS), which refer to credit lines and guarantee schemes for the support of the domestic economy and the public sector, including financing for the use of renewable energy sources.

The **EBRD** supports and promotes energy efficiency in BiH with loans for financing the implementation of advanced energy-saving measures that are part of the program of direct financing of sustainable energy projects for the Western Balkans. EBRD provides credit lines to local banks in BiH for lending to private and municipal users of investments in energy efficiency and renewable energy sources, all with the aim of economical use of energy. In addition to the above, the EBRD also provides direct financing of large projects related to RES.

The credit line of the **Green Economy Financing Facility (GEFF)** and the EBRD in the Western Balkans is intended for financial support of the housing sector for EE and OIE projects. GEFF&EBRD grants loans through local commercial banks and microcredit organizations (UniCredit bank d.d. Mostar and UniCredit bank a.d. Banja Luka, ProCredit BiH, Sparkasse Bank, MKF Partner).

Western Balkans Sustainable Energy Financing Facilities (WeBSEFF) is a credit line intended for financial institutions present in the countries of the Western Balkans for loans to companies and municipalities investing in EE and OIE projects. Credit lines are available to both the public and private sectors through local commercial banks. [10]

6. Conclusion

The main goal of this paper is to explore the potential of the construction of Solar power plants in the Una-Sana. Canton. As an answer to this question detailed research of the solar technologies and their advantages and disadvantages, legal framework, and geographical and administrative-technical of Una-Sana Canton was carried out and the following is concluded:

- Although Monocrystalline panels have the highest price currently on the market, their long-term benefits are worth the investment since they offer the highest efficiency rates and power output.
- The main advantage of solar power plants is the fact that solar energy, is a renewable energy source and doesn't have any negative effect on the environment. In addition, after the initial purchase cost, SPPs have relatively low maintenance costs and a long lifespan.
- The main disadvantages of solar power plants are the initial cost of purchasing a solar system, the fact that the solar systems are relatively weather dependent, and that the energy storage can be expensive.
- Una Sana Canton has natural and technical capabilities for the construction of solar power plants.
- The biggest challenge for the construction of solar power plants in the Una-Sana Canton is the insufficient capacity on the distribution network, for which the Elektrodistribucija Bihać can directly issue the power consent.
- In the past three years, the construction of solar power plants has significantly increased.
- There are several financing models and sources of financing that can be used for renewable energy sources, thus the construction of solar power plants.

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Foundations of theory of language contacts

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Abstract. In this paper, we analyze various aspects of language contact, including the reasons and needs for borrowing words. Words of foreign origin often enter the language to denote new technologies or cultures, or simply to fill gaps in the vocabulary. This process of lexical borrowing can happen in different ways and at different periods of language development. Through a thorough understanding of the principles of contact linguistics, we can better understand the dynamics of language in interaction and preserve and promote linguistic diversity in a world that is constantly connected. Considering language contacts helps us to understand how languages enrich each other and develop new lexis, but it can also open questions about the preservation of linguistic identity in a contemporary global society. Through further analysis and examples, we explore different types of linguistic loanwords and their impact on target languages and their adaptation to new linguistic environments. Overall, understanding the theoretical foundations of contact linguistics helps us delve deeper into the complexity of linguistic interactions and understand their importance for intercultural communication.

1. Introduction

Contact linguistics is a scientific field that studies language changes that occur when different languages come into contact. Contact linguistics is a key branch of linguistics that studies language contacts and their consequences for language diversity. By focusing on language change, word borrowing, and the exchange of language patterns, contact linguistics provides insight into the complexity of interactions between languages and cultures. It also considers the importance of studying contact phenomena in contemporary globalized society, where language contacts often occur and affect the identity of individuals and communities. Through a thorough understanding of the principles of contact linguistics, an insight into the dynamics of languages in mutual interaction is opened. This actively contributes to the preservation and promotion of linguistic diversity in today's globally connected world.

2. Understanding language contact

The basic concept of contact linguistics is *language touch* or *language contact*, for which we unfortunately do not find unambiguous definitions in the literature.

In the *Metzler Lexikon Sprache* [1] we find the following definition of the word *Sprachkontakt* (language contact):

> *«Das Aufeinandertreffen zweier oder mehrerer Sprachen meist durch geographische Nachbarschaft ihrer Sprecher. Vorraussetzung ist, dass Kommunikation über die Grenzen der jeweiligen einzelnen Sprachgemeinschaft hinweg erfolgt.». (Author's translation: The contact of two or more languages is most often the result of the geographical proximity of their speakers. A prerequisite is the establishment of communication across the borders of individual language areas.)*

Its definition implies more that it is "mutual contact" of two or more languages. The consequences of language contact include bilingualism, interference, language mixing, the emergence of a language alliance, and language replacement.

In the *Lexikon der Sprachwissenschaft* [2] we find a definition of the word *Sprachkontakt* (language contact):

> *«Koexistenz zweier oder mehrerer Sprachen innerhalb einer Sprachgemeinschaft, deren Sprecher diese Sprachen alternativ verwenden». (Author's translation: Language contact is the coexistence of two or more languages within one language community, whose speakers use these languages alternatively.)*

This definition confirms the opinion of other linguists that participants in language contacts are not all speakers, but bilingual speakers, i.e., those who use at least two languages actively in certain situations.

David Crystal [3] in *A dictionary of linguistics* and phonetics, using the term contact, refers to "a situation of geographical continuity or close social proximity (and thus mutual influence) between languages or dialects". He further points out that the result of contact situations can be reflected linguistically, in an increase in the number of loanwords, patterns of phonological and grammatical change, mixed forms of language, and a general increase in bilingualism of various kinds.

Hermann Paul [4] in the work *Prinzipien der Sprachgeschichte* using the term *Sprachmischung* (mixing of languages) considers that language contact occurs as soon as two people start a conversation:

> *«Gehen wir davon aus, dass es nur Individualsprachen gibt, so können wir sagen, dass Sprachmischung stattfindet, sobald sich überhaupt zwei Individuen miteinander unterhalten.». (Author's translation: If we assume that there are only individual languages, then language mixing occurs when two individuals start a conversation.)*

Paul believes that the condition for language mixing and language contact is that a person has a certain minimum mastery of a foreign language for language contact to occur.

Uriel Weinreich's work *Jezici u kontaktu* (*Languages in Contact)* [5], first published in 1953, is of central importance for research on the concept of language contact and bilingualism. In the translated work *Sprachen in Kontakt* it is stated:

> *«Die Praxis, abwechselnd zwei Sprachen zu gebrauchen, soll Zweisprachigkeit heißen, die an solcher Praxis beteiligten Personen werden zweisprachig genannt.».*

According to Uriel Weinreich, languages in contact are those used interchangeably by the same speaker. He calls that person *bilingual*, and the phenomenon *bilingualism*. The consequence of this phenomenon that one speaker uses more than one language is called *interference*.

Leonard Bloomfield [6] also wrote about language contact and transfer from one language group to another in his work *Language*. He uses the term *culture borrowing*. The very term "cultural" indicates that language contact is related to extra-linguistic factors. Bloomfield limits himself to the cultural causes of language contact and introduces that each language community learns from its neighbors. Cultural and civilizational achievements of one language community are transferred to other language communities.

According to Rudolf Filipović [7], language contact is:

> *«Kada se neka riječ ili fraza jezika davatelja preuzme u jezik primatelja ili kada govornik odluči naučiti strani jezik. Njegova definicija također upućuje na dvojaku prirodu jezičkog kontakta: individualnu i kolektivnu.». (Author's translation: when a word or phrase of the donor language is adopted into the recipient language or when the speaker decides to learn a foreign language. His definition also points to the dual nature of language contact: individual and collective.)*

Bechert and Wildgen [8] state three levels at which language contacts occur: the level of speech (parole), the level of language (langue) and the level of language development, which refers to the diachronic development of language systems in intensive contacts with other language systems after a long period of influence of language contacts.

In the area related to language contacts, various typologies of language contacts have developed. Asim Peco [9] breaks down language contacts into three types: migratory type of contact, non-permanent contact type and permanent boundary type of contact. He takes the consequences of linguistic contact as the main criterion of his classification, i.e., whether there is language contact only at the

lexical level, whether there are structural changes in the language or even bilingualism. K. Ehlich [10] distinguishes up to ten types of language contact.

According to all the above, we can conclude that the term language contact or language touch is an abstract term that denotes contact or communication between speakers of different languages, whether it is active communication or passive exposure to a language that is not the speaker's native language.

3. Contact Linguistics

The branch of linguistics that deals with issues related to the research of language contacts in the Bosnian language is usually called the theory of language in contact, after the title of Rudolf Filipović's book Theory of Language in Contact [7], the creator of the basic model of the study of foreign linguistic elements in the Bosnian-Croatian-Serbian languages. The term Bosnian/Croatian/Serbian language was used according to the example and goal of Midhat Riđanović [11], who in his work *Language and its structure* justifies replacing the name of the language "Serbian-Croatian language" with the name b,h,s. "The language used in the areas of Bosnia and Herzegovina in the former Yugoslavia was usually called Serbian-Croatian. The result of the creation of new states on the territory of the former Yugoslavia was the officialization of the new names of their languages: Bosnian, Croatian, and Serbian." For the above reasons, such a name is used in this part of the paper, considering that the published books and findings also refer to the Bosnian language, which is the subject of this paper. If, however, something refers only to the Croatian, or only to the Serbian, or only to the Bosnian language, the corresponding name of the language is used.

In his introductory part of the monograph, Rudolf Filipović [7] notes that he took the term from the title of Uriel Weinreich's work *Jezici u kontaktu (Languages in Contact)*. He believes that the terms *linguistic* or *language borrowing* are imprecise and that the term *languages in contact* gives a broader meaning. For these reasons, he introduces the term *language contacts*, referring to the branch of linguistics that investigates language contacts in theory and application. This branch of linguistics encompasses and studies the entire area of *language contact* and *language conflict*, bilingualism and multilingualism, translation and acquisition of other languages, all forms of interference that occur because of language contact and cultures at all levels. It seems to us that these listed and many other reasons justified the formation of a special branch of linguistics.

Lots of other linguists have contributed to this field. Other terms such as *kontaktna lingvistika* (contact linguistics), *lingvistika jezičkih kontakata* (linguistics of language contacts) or *kontaktologija* (contactology) have been expanded over time, and recently the terms *lingvistika jezičkih dodira* (linguistics of linguistic contact) and *dodirna lingvistika* (contact linguistics) have been increasingly used. Among Bosnian linguists, there is no single point of view as to which term would be the most acceptable, although the term *kontaktologija* (contactology) seems practical to us due to its singleness and creative fertility *kontaktolog* (contactologist), *kontaktološki* (contactology).

Wildgen [12] defines contact linguistics as an area of interaction between the humanities and social sciences and emphasizes the importance of macrogeographical and macrocultural structures and individual psychological and microphysiological processes.

Piškorec [13] defines contact linguistics as a discipline in which psycholinguistic and sociolinguistic, anthropological, communicative, and literary-scientific approaches and methods find their place.

Under *kontaktologija* (Contact Linguistics), Rudolf Filipović [7] believes that it is:

> *«Grana lingvistike koja na osnovu rezultata istraživanja tih kontakata formulira lingvističke principe vezane uz bilingvizam, jezičko posuđivanje, usvajanje jezika, gubljenje jezika, napuštanje jednog u korist drugog, pod pritiskom dominantnog jezika ili jezika prestiža, jezičko planiranje itd.». (Author's translation: "a branch of linguistics that, based on the results of the research of those contacts, formulates linguistic principles related to bilingualism, language borrowing, language acquisition, language loss, abandoning one in favor of another, under the pressure of a dominant language or a language of prestige, language planning, etc.")*

4. Linguistic borrowing

Elements of all language levels can be borrowed, i.e., each linguistic unit (phoneme, morpheme, lexeme, syntagm, phrase, sentence...) can be taken from one language to another, become an integral part of that

language and influence the expansion of the linguistic fund and other segments as well as any native linguistic unit. However, research has shown that borrowing most often takes place at the lexical level. During language contacts, the lexicon is first borrowed, and only in the case of longer and more intense contact, phonemes, morphemes, or other features are borrowed.

Meillet, like many other linguists, considers lexical borrowing to be completely natural, but he considers borrowing in sounds and grammar to be rare. He argues his claims as follows: "Each language is a system, and bilingual speakers who have a choice of two languages do not mix those two languages." He further asserts that pronunciation and grammar form a closed system and finally concludes that the subject of borrowing is exactly vocabulary elements and that there is no language whose lexicon does not contain loanwords.

Indispensable literature when it comes to linguistic borrowing is the work *Prinzipien der Sprachgeschichte* (Principles of Language History) by Hermann Paul [4]. According to him, the consequences of language contact are "language mixing" (Sprachmischung) and "mixed languages" (Mischsprache). He believes that the mixing of languages is essential for the life of the language. In his work, he develops the principles of linguistic borrowing and defines the influence of language mixing as one language influencing another if the other receives foreign material and if its own linguistic material is formed according to foreign models.

He further states that linguistic borrowing can be the result of necessity and fashion. In further exposition, Paul describes the entry of a foreign word into the recipient language. He uses the term *sound substitution* when it comes to modifying the form of words. Under the title of *voice substitution* (Lautsubstitution), he presents the principles according to which, from the point of view of the voice system, loanwords are included in the system of the recipient's language.

In the middle of the 19th century, there were fierce discussions about the problem of *mixing languages*. Meillet, Schönfelder, Haugen as well as many other linguists criticize the use of the term *mixing languages*, they consider it unsuitable and unrealistic. Their research shows that in most cases lexical elements are mixed, but this is not the case with phonological, morphological, or syntactic elements.

For these reasons, K. H. Schönfelder [14] distinguishes the acquisition of lexical elements from others, and he means by the term *mixing languages* when, in addition to lexical elements, there is also the acquisition of other grammatical elements. He calls *borrowing* when there is acquisition of only lexical elements.

E. Haugen, warning against weakness and incorrectness, suggests rejecting the term *mixing* and suggests the term *borrowing*. In his theoretical article *The Analysis of Linguistic Borrowing*, he precisely defines the term *linguistic borrowing* and describes it as a process that takes place when a bilingual speaker reproduces a sample of one language in another. His terminology finally leads to the replacement of the previously established term *language mixing* with the new name *language borrowing,* which is still used today.

Leaning on Haugen's theory, Rudolf Filipović [7] defines linguistic borrowing as follows:

> *«Kad je element X prešao iz jezika davalaca u jezik primalaca ili je jezik primalac posudio element X od jezika davalaca, kažemo da je nastupila interferencija između jezika davalaca i jezika primalaca.». (Author's translation: "When element X has passed from the donor language to the recipient language or the recipient language has borrowed element X from the donor language, we say that interference has occurred between the donor language and the recipient language.")*

5. Lexical borrowing and types of lexical borrowings

There are different types of lexical loanwords. Most often, they are borrowed as a whole, that is, an expression with its associated content, but it is also possible to borrow only the content that is then joined to an already existing native word. In that case, we are talking about *semantic borrowing* and *semantic loanwords.* A special type of borrowing is the translation of language signs by lexical means of the recipient language. We call them *prevedenice* (translations) or *kalkovi* (calques). So, by lexical borrowing we mean taking over a lexical unit, its expression or content, or even both expression and content [15].

Names or terms that refer to lexical units taken from other languages, such as *posuđenice* (loanwords), *tuđice* (foreign words), *usvojenice* (adopted words), *pozajmljenice* (borrowed words), *strane riječi* (foreign words), *strani leksik* (foreign lexicon), *prevedenice* (translations), etc., are unevenly used, defined, and classified differently. This results from different criteria, according to which lexical units are classified and with what intention they are researched and analyzed. According to all the above, various methodologies and typologies are conceived.

Research papers that thematize the lexical research of foreign words in the Bosnian language are primarily conceived with the theoretical basis of Rudolf Filipović's study *Jezici u kontaktu (Language in Contact)*, that is, with his terminology and model of linguistic borrowing. Although we cannot list all the existing terms, methods, and classifications of lexical borrowing, on this occasion we will present those that we consider to be the most important and relevant for this research.

On linguistic borrowing, Filipović points out three basic elements from which any linguistic research should start. Relying on the opinion of Uriel Weinreich, Filipović points out that languages in contact are those that are used alternately by the same speaker. He calls that person *bilingva (bilingual)*, and that phenomenon *bilingvizam (bilingualism)*. The consequence of this phenomenon that one speaker uses more than one language is called *interferencija (interference)*.

The element (word) X as pronounced by speakers of the donor language is called a *model*, and the borrowed element as pronounced by speakers of the recipient language is called a *replica*.

When two language systems come into mutual contact, words from one language are taken over into the other. The two languages that participate in this process are called the *donor language* and the *recipient language.*

When receiving lexemes from the donor language to the recipient language, certain changes occur at different levels. Regardless of the levels, overall changes can be globally divided into two groups: *primary* and *secondary*. Therefore, we distinguish between primary and secondary adaptation, according to Filipović's model. The term *faza (phase)* is used to describe the duration of the change process, either model or replica. In the phase of primary adaptation, foreign loanwords are adapted to the system of the receiving language, while in the phase of secondary adaptation, they become subject to changes at different levels, like any other native word. All changes that occur before the creation of the replica are called *primary adaptation*, and all changes that follow the replica are considered *secondary adaptation*.

The primary adaptation is clearly defined. It begins with the entry of a foreign model into the Bosnian linguistic system of the recipient language and ends with the formation of a replica. Secondary adaptation is clear only as far as genesis is concerned. The ending cannot be determined because the replica can change during the development of the recipient language. These changes are no longer associated with the foreign language because they are always bound only within the language system of the recipient and according to its rules.

Filipović [7] distinguishes four ways of adaptation through which the model goes: phonological, orthographic, morphological, and semantic. According to these levels, the processes are named: *transfonemizacija (transphonemization), transmorfemizacija (transmorphemization) i transsemantizacija (transsemanticization).* (Filipović: 1986)

6. Reasons for lexical borrowing

B/h/s lexicological literature usually divides the reasons for lexical borrowing into extra-linguistic and intra-linguistic ones, such as political, commercial, cultural-civilizational ties or geographical proximity between two linguistic communities, and intra-linguistic ones that refer to empty places in the system that are filled with ready-made solutions from other languages [16].

Rudolf Filipović [7] believes that linguistic borrowing can occur from a simple need to name an object or an invention that was taken from another, often materially superior culture, because as a result of it taking over, there was an "empty place" in the recipient's language system. In addition, linguistic borrowing can also be the result of fashion.

Weinreich [5] explains lexical borrowing by the universal need to name new entities. He also lists several intra-linguistic motives for borrowing: the frequency of certain words, harmful homonymy, the constant need for synonymy. From the psycholinguistic motives, he highlights insufficient

differentiation of certain fields of meaning, the social status of the language of the giver or receiver, as well as the sheer carelessness of the speaker.

E. Öhmann distinguishes *luxury* and *necessary loanwords* (Luxuslehnwörter und Bedürfnislehnwörter). *Luxury loanwords* are those for which there is already a domestic equivalent, so the loanword is "redundant". And *necessary loanwords* are those for which there is no adequate substitute in the recipient language, and there is a reason for borrowing and justification to fill a lexical gap in the recipient language [17].

Bloomfield (1933) uses the term *cultural borrowing* for justified borrowing. He also mentions *intimate* and *dialectal borrowing*.

R. Deroy explains the reasons for lexical borrowing with the terms: practical necessity and emotional needs. Practical necessity motivated the borrowing of lexemes to denote new entities. Borrowing due to emotional needs refers to borrowing caused by psycholinguistic and sociolinguistic reasons, such as the prestige of the provider's language [17].

Starting from the knowledge that words are not borrowed only to name something new, but that borrowing can also be motivated by the connotative and emotional value of the word. E. Andrić (1996) lists a number of reasons for lexical borrowing: naming new things and concepts; taking over foreign words in the interest of precise expression; expressing belonging to a group connected by common interests; expressing closeness; intimacy; facilitating communication; arousing the attention of listeners or readers; the desire to achieve diversity in language; lack of language culture and carelessness; the desire to identify and imitate a famous person; not knowing an adequate native word; not knowing the exact meaning of a foreign word and therefore not being able to replace it with an adequate native word; conscious adaptation to a higher or lower level of expression of the interlocutor [17].

Some linguists do not accept all motives for borrowing foreign words. Many are of the opinion that there is no need for a foreign lexicon if there is an adequate replacement. On the basis of purist literature, Samardžija (1998:63) establishes the rules regarding the acceptance and non-acceptance of loanwords:

> *«Posuđenice su jeziku potrebne ako za njih nema domaće zamjene ili je zamjena zastarjela. Postoji li domaća zamjena opsegom svoga sadržaja ista posuđenici, odnosno radi li se o sinonimima, prednost u upotrebi ima domaća riječ. Ako je opseg sadržaja posuđenice širi ili uži od opsega sadržaja domaćeg leksema, treba je upotrijebiti samo onda kada je domaći leksem ne može zamijeniti ». (Author's translation: "Languages need loanwords if there is no native substitute for them or if the substitute is outdated. If there is a domestic replacement with the same scope of content as loanwords, that is, if they are synonyms, the domestic word has priority in use. If the scope of the content of the loanword is wider or narrower than the scope of the content of the local lexeme, it should be used only when the local lexeme cannot replace it »)*

On the other hand, many linguists justify borrowing for any reason by arguing that all borrowing is done for a reason and that lexical borrowing always fulfills some communicative need and thus becomes justified.

7. Conclusion

From the analysis of definitions and theoretical approaches to language contact, it emerges that the notion of language contact is a complex and multi-meaning concept. The study of lexical loanwords, which has a central place in the tradition of contact linguistics, is particularly noteworthy. Given the openness of the lexical subsystem of the language, there is almost no language that does not contain at least one unit taken from other languages.

The opening of the lexical subsystem stems from its nature and distinguishes the lexical system from structurally more strictly defined phonological, morphological, or syntactic systems within the language. One of the key reasons for borrowing lexemes is their denotative function, i.e., the ability to always refer words to extra-linguistic reality. As society progresses and develops new things and concepts, the need to create new lexemes through creation or borrowing also arises.

By studying language contact and borrowing, linguists can better understand language interactions, cultural exchanges, and historical influences. Through this process, languages are enriched with new contents and become more and more diverse. But at the same time, language contact can lead to certain challenges, such as language mixtures, language disappearance or language dominance.

In conclusion, the theoretical foundations of contact linguistics provide a deeper understanding of the complex processes of language interaction. The term "language contact" encompasses various situations and effects of language encounters, while language borrowing stands out as an important phenomenon in that context. This field of linguistics has an important role in the study of language changes and the dynamics of different languages in contact with each other. Through further research, contact linguistics will continue to contribute to our understanding of linguistic diversity and language development in a multicultural world.

With all the above, it is important to emphasize that language contact is not a one-way phenomenon. Rather, it represents a two-way interaction between languages, where both languages can borrow from and influence each other. All these characteristics make the study of language contact a challenging, but at the same time extremely interesting area of linguistics that helps us better understand the diversity and complexity of human languages.

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LINUM USITATISSIMUM – forgotten and unterutilized culture

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Abstract. Synthetic fibers have completely suppressed the production of natural flax fibers, but since they are not biodegradable and environmentally safe, flax fiber re-cultivation and use of flaxseed fibres occur, and today in the EU they are increasingly in demand for the construction of biological hard packaging, furniture, but also the interior of cars. The northwestern part of Bosnia and Herzegovina represents ideal conditions for the cultivation of this, somewhat forgotten culture, but the only area sown with flax on the territory of the Una-Sana Canton are located on the territory of the municipality of Bosanski Petrovac. Since flax can be used in a number of ways, because of its multifaceted role, and because of its properties and nutritional values, it promotes health , we believe that he has been assured a better future, and a deserved place in plant production.

1.Introduction

Flax is a multipurpose plant whose long fibers are used in the textile industry, and short for the production of papers, materials for isolation and production of biocompost (Czempik et al., 2011). Due to the versatile application, pallets of cosmetic and pharmaceutical products have been developed today, and flax seeds are used in different ways in the diet: mixing in pastries, cakes, etc., (Šimetić, 2008). Oil from seeds is obtained by cold pressing, and is rich in omega -3 fatty acids, which has multiple positive effects on human health, like lowering cholesterol in the blood (Nožinić et al., 2022). After World War II, flax fibers were completely suppressed and replaced by cheap synthetic fibers. However, the dwindling supply of non-renewable resources and various environmental problems arising from the production and disposal of synthetic materials they have regained interest in the use of natural fibers. In the countries of Western Europe and the USA, flax cultivation and development of new processing procedures are invested significant funds to encourage the use of linen fibers for textile, but also for technical and composite materials. According to EU guidelines, 95% of every new car must be recyclable, which is why it is recommended to use natural fibres, especially flax, for making the interior of the car, and because of their elasticity they are much more favorable than synthetic or glass fibers (Darja Kočjan-Ačko, 2010). New findings on the importance of natural fibres as renewable, biodegradable and environmentally friendly materials, expanding the area of their use, as well as the expansion of the use value of flax seeds influenced the restoration of flax production in the world at the end of the 20th century, but also in our regions (Nožinić et al., 2013).

The characteristic and advantage of flax fiber over other natural fibers is less absorption of water into cellulose fibers which leads to the extraction of hemicellulose, degradation of hemicellulose and lignin, and an increase in cellulose crispness, resulting in increased strength (firmness). When it comes to the production of flax fiber, the leading place is occupied by China, followed by Belarus, France, Russia, Belgium, Great Britain, i.e. places where favorable conditions prevail for growing flax, moderately warm summers with an average precipitation rate of 1100 to 1400 mm (Darja Kočjan Ačko & Rijavec, 2010).

2. Objective and task of the work

Assessment of agronomic characteristics of 2 varieties of flax cultivars using the traditional method of extracting fibers from stems.

3. Materials and methodes

For research, flax plants of the Belstar and Viola varieties were grown in field conditions up to the stage of early yellow ripening. On a sample of 30 plants, phenological characteristics were determined: plant height from cotyledon nodium to the top of the plant, as well as branching. Using a roller mill, the woody part of the stem was separated and used for further analysis, as well as the separation of fibers.

2.1. Maceration

The selected samples were dried on the ground for about 10 days with occasional turning of the bundles, and were subjected to biological maceration, in the manner of firmly connecting the bundles with a wire and deposited at the bottom of a local stream, so that the normal flow of water is not disturbed. After soaking for 10 days (pulling the stem between the thumb and forefinger makes the fiber easy to separate and does not curl), the plants were washed, placed in a compartment and dried for several days.

2.2. Separation of the fibers

Applying the traditional method of using a hand-made breaker popularly known as a "stupa", then rubbing it on a "trlica" also made by hand consisting of a pair of knives, the broken stalks of flax are passed several times between a pair of knives, during which the pozder breaks. into smaller parts and remove one part from the fibers. The flax stalks thus prepared are then passed through hand combs (a pair of steel teeth attached to a board at a distance of 3 mm). In this way, the husk is separated from the fibers and the short fibers are separated - the pulp, and the long fibers are formed into a bundle.

2.2.1. Examination of fiber quality

To define and categorize flax fibers, technological features were determined: The length and thickness of long fibers in relation to the initial mass of the tested samples was determined according to the method defined by the standard (SRPS F.S2.211, 1963), while the fineness of the fibers according to the method (SRPS F. S2.212, 1963). The elasticity of the fibers was determined using a dynamometer. The results were processed with the help of the statistical program Past 2021.

4. Research results with discussion

Based on the results of a one-year research on phenological and textile-technological properties, it was determined that there are significant differences between the tested varieties. For fine flax, the height of the plant itself, i.e. the length of the stem, is particularly important because it directly affects the content of long fibers, which are also the most important raw material for the textile industry. The average height of the flax plant was for the variety Belstar (88.4 cm), while for the variety Viola the measured stem length was 90.6 cm. Given thata) recommend a technical stem length of over 60 cm, because such stems form longer and better quality fibers suitable for technical processing, we can say that both tested varieties met the basic technical standards of textile plants.

The variety Belstar in all tested samples achieved greater branching of the saber with an average value of twigs of 22.21 cm, compared to the variety Viola 18.23 cm. Branching of the stem is a genetic

trait, which is proven by the research of Countre et al., (2002), and confirmed by the research of Kocjan-Ačko and Trdan (2008), where the examined cultivars did not form branches at a larger inter-row distance. The most important factor in the cultivation of fine flax is the content of long fibers in the stalk. Research by Lazić et al. (2017) report the content of long fibers for the Viola variety at 88.05%, while research by Dervišević et al. (2013) report data for the Belstar variety in the amount of 72.8%. By comparison with the data from the literature, the results achieved by this research are significantly lower, and the values for the variety Viola are 81.06%, and for the variety Bilstar 69.9%. We explain the lower results due to unfavorable climatic conditions during the experiment (significantly lower rainfall than average during May and June 2021), but by applying appropriate measures and improvements during cultivation, these results could probably be improved while avoiding the cultivation of tulip plants according to the principles of dry farming.

Tabel 1. Properties of the tested fibers

Variety of flax	Fiber lenght	Fiber thickness μ	Fiber elasticity
Belstar	$\bar{x}$=26,42 SD=3,51	$\bar{x}$=0,028 SD=0,04	$\bar{x}$=10,75 SD=3,89
Viola	$\bar{x}$=34,2 SD=2,86	$\bar{x}$=0,022 SD=0,08	$\bar{x}$=9 SD=1,414

Kocjan and Rijavac (2010) investigated the characteristics of domestic flax in the area of Bjela Krajina, and the measured average length of technical textile fibers of domestic flax was 19 cm. Comparing the results of the research, both tested varieties met the basic regulations. The most important feature of the fiber is the fineness of the fiber, and the smaller the cross-sectional area, the thinner the fiber, and therefore finer. By comparing the fiber thickness between the tested varieties, the differences shown in table 1 were determined. The Viola variety had lower average fiber thickness values compared to the other tested variety, which the statistical processing of the significance of the results at the significance level of 0.01 proves statistically significant differences. It is desirable that the fibers have a high tensile strength along their length, while research by Han (2005) concludes that in addition to the genetic trait, the cellulose and hemicellulose content is also influenced by the method of wetting. In the conducted research, an intensive wetting method was applied, and the differences in the elasticity of the fibers are attributed to varietal characteristics.

5. Conclusion

Based on the results of the fiber quality check during the one-year research, the examined varieties achieved satisfactory results, where the Belstar variety formed slightly coarser fibers, and the Viola variety more delicate fibers. This variety is characterized by the most important feature imposed by the textile industry, which is the fineness of the fibers.

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Monitoring of airpollutants of trees and grass in the urban ecosystem of the city of Bihać and their impact on human health

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Abstract. Urban ecosystems are areas where there are large numbers of people. Also, in such areas, in addition to other pollution, air pollution with air pollutants is also present. Due to this fact, air pollutant monitoring is a very important segment of general environmental monitoring. Aeropollutants that have recently attracted special attention in addition to weeds are also the pollen grains of trees and grasses. Their high concentrations of pollen grains are especially present at the time of their pollution. Nowadays, tree and grass pollen grains are also of great interest to scientists and researchers regarding the effects of their high concentrations on human health. Since 2008, the concentration of pollen in the air has been regularly monitored in the area of the urban ecosystem of the city of Bihać. The equipment used for the research included a Hirst type pollen trap (sampler) Burkad. In general, the aim of this work was based on the presentation of pollen dynamics of aeropollutants, especially trees and grasses, over many years. In this research, the period of monitoring of pollen dynamics was from 2012 to 2022. Research has shown that the highest annual concentrations of tree (birch) pollen were present from April (second half) and May and June. In the observed period, the total prevalence of tree and grass pollen was about 40% compared to 60% of weeds.

1. Introduction

Urban ecosystems are the areas with a large concentration of people and other organisms (plants, animals, microorganisms). Within such ecosystems, there is a mutual dependence between organisms and their environment. A subject of interest of such ecosystems and their characteristics is in the domain of urban ecology as a subdiscipline [12]. There are several definitions of urban ecology. According to [1] urban ecology is the study of the mutual evolution of man and nature in urbanized regions. According to [12], urban ecology integrates problem-oriented research of natural and social sciences and thus clarifies mutual dependence within the urban ecosystem in several dimensions.

It is widely recognized that cities are actually urban ecosystems. Today's problems of cities, in addition to congestion, devastation, noise, emissions, high concentrations of pollution, are also problems of lack of green spaces, as well as the occurrence of invasive plant species in green spaces. It is known that green spaces are aesthetically pleasant democratic places where people meet and as such have a direct impact on temperature balance, air humidity, dust reduction, regulation of wind flow and create sound protection against noise [4, 15]. According to [8], it states that in addition to the impact on the environment, green spaces have a direct and indirect impact on the mental and physical health of the

population. The direct impact of green spaces is reflected in recreation, social contacts, relaxation, walking, stress reduction, and such. The indirect impact is reflected through the control of pollutants as well as through the maintenance of air humidity, reduction of dust, temperature and noise, etc.

It is known, in addition to other plant species, that the birch tree (*Betula pendula*) and grasses (*Poaceae*) have a very high pollen allergy potential[1] and that such plant species are one of the strongest aeroallergens in the environment [9]. Birch (*Betula pendula*) tree grows only in the northern hemisphere, pollinated by wind (anemophile). Birch pollen has a high allergic potential. It is usually grown in cities as an ornamental tree. Grasses (family *Poaceae*) are the most important cause of pollinosis in Europe. Grass pollen is a strong aeroallergen – it has a high allergic potential (Figure 1-2). Depending on the type of grass, it is pollinated by wind (anemophile), water (hydrophile) or with the help of organisms (zoidophile).

Therefore, attention should be paid to allergenic plant species and to what extent they are found in green spaces of urban ecosystems.

Figure 1-2. Birch *Betula pendula* (left) and grasses *Poaceae* (right) in urban ecosystem – Bihać.

2. Monitoring of plant allergenic airpolutants

Daily measurements of pollen concentration in the air are carried out in most European countries that are members of the European Aeroallergen Network (EAN). Daily monitoring of pollen concentrations in the air allows presenting the dynamics of pollen spread with an emphasis on highly allergenic pollen recommended by the International Association for Aerobiology (IAA).

The results are presented to the public in the form of daily allergy traffic lights, maps and/or pollen forecasts for a certain period of time. In many cities of Bosnia and Herzegovina, the problem of airpollutants and their monitoring is widely present. In the Federation of Bosnia and Herzegovina (F BH), according to data from the Federal Hydrometeorological Institute, for the cities located in the F BH, in the biometeorology segment, there is information on the pollen forecast - maps on birch, olive, grass and weed[2] allergens, where, among other things, there is a note about them.

Since 2008 monitoring of airpollutants has been carried out in Bihać as an urban ecosystem - pollen specifically for plant species: trees birch (*Betula pendula* and other trees), grasses (*Poaceae*) and weeds (*Ambrosia artemisiifolia* L. and other weeds).

3. The effect of airpollution on human health

Airpollution is considered a provocative factor in the development of allergic diseases [7]. However, air pollution is considered one of the important factors responsible for the increase in allergic diseases. Airpollutants can be of natural and anthropogenic origin [18], but it is still unclear how they modify the immune response [6]. Airpollutants are also called allergens of outdoor spaces, which are counted among environmental factors, and which include pollen in addition to tobacco smoke, parasites and others [11], where even short-term exposure of the organism to airpollution can cause acute symptoms

[1] Source: http://alerix.ba/najcesce-alergogene-biljke/ (available: 28.04.2023)
[2] Source: https://www.fhmzbih.gov.ba/latinica/BIO/peludna_za_web.php (available: 28.04.2023)

[3]. The main plant allergenic airpollutants in the environment are tree, grass and weed pollen. Depending on the latitude and atmospheric conditions, their concentration and pollen maps vary [2].

In general, in developed countries, pollen is the strongest natural aeroallergen and the most common cause of allergic diseases of the respiratory system. Due to their size, the pollen grains do not penetrate deep into the respiratory tract, but affect the eyes, nose and nasal cavity [5]. The most common symptoms are: Allergic rhinitis, Allergic conjunctivitis and Asthma. Symptoms are most often associated with environmental factors as well as with a genetic basis, and their treatment most often includes primary prevention (avoidance of allergens), education, control measures, etc. [10, 16, 17].
Most plants release pollen grains early in the morning during sunny days [11]. Data on daily pollen concentration trends are important in the assessment of exposure to allergens. They are given in the form of an allergy traffic light and pollen forecast for a certain period of time.

The allergy traffic light is a way of daily reporting on the amount of pollen in the air in a certain area. The colours of the allergy traffic light are most often white, green, yellow, red and purple, accompanied by explanations about the occurrence of symptoms. The pollen calendar is a graphic representation of the pollen spectrum in the air of a certain area in a certain period of time (most often for a year). It gives information about the beginning, duration and end of pollination of a plant species in a certain area.

There is also information on the classification of many plant species in relation to the allergic potential of pollen. In general, all information about the presence and dynamics of the spread of allergenic pollen in the air is of primary importance both for doctors and for people who are allergic [5].

3. Material and methods

Ragweed pollen sampling methodology as defined by the International Aerobiology Association was used. The Concentration of pollen was measured by standard Hirst's (1952) method. Sampling of aeroallergenic ragweed pollen was performed during the pollination in the period of 2012-2022. Equipment used for research included a Hirst type pollen trap (sampler) Burkad (Figure 3), placed in the town of Bihać (locality Borići), 15 meters above the ground.

Figure 3. Burkad type pollen sampler.

Counting and visual identification of ragweed pollen was performed with a light microscope at a magnification of x400. Mathematical formulas were used to calculate the concentration of pollen grains in the air.

$$P_{observed} = r \quad xb \quad x \quad c_{sum} \tag{1}$$

$$CF = \frac{P_t}{P_p} \tag{2}$$

X – concentration of airborne pollen grains (grains/m^3)

$$X = \frac{CF \quad x \quad pollen \quad grein}{14{,}4m^3} \tag{3}$$

For determining the concentration the following parameters were into account:

r – diameter of the microscope field (r=0,5mm);
b - the length of the sampling strip (b=48mm)
P_t – area of strip (total area);
c_{sum} – number of strips that are observed (three strips);
P_p – area of the microscope field (observed area);
CF – correlation factor (CF = 9,3).

The obtained results were interpreted using the „pollen semaphore“ scale (a color-based assessment scale) with relevant percentage of individuals that are likely to develop allergy symptoms (Table 1).

Table 1. Criteria for estimating the pollen concentration in air.[3]

Pollen concentration (color)	Number of pollen in the air (grains/m^3)			The appearance of symptoms of allergic reactions
	Tree	Grasses	Weeds	
Not present (white)	0	0	0	No symptoms
Low (green)	1-15	1-5	1-10	Only in people who are very sensitive to aeroallergens
Moderate (yellow)	16-90	6-20	11-50	In many people who are sensitive to aeroallergens
High (red)	91-1500	21-200	51-500	In most allergic people
Very high (purple)	> 1500	> 200	> 500	In all allergic people

4. Work results with discussion

The results of airpollutant monitoring in the period from 2012 to 2022 in the urban ecosystem of the city of Bihać are presented graphically for the birch tree *Betula Pendula* (Figure 4), for the *Poaceae* grasses (Figure 5) and the summary percentage ratio of different types of pollen (Figure 6).

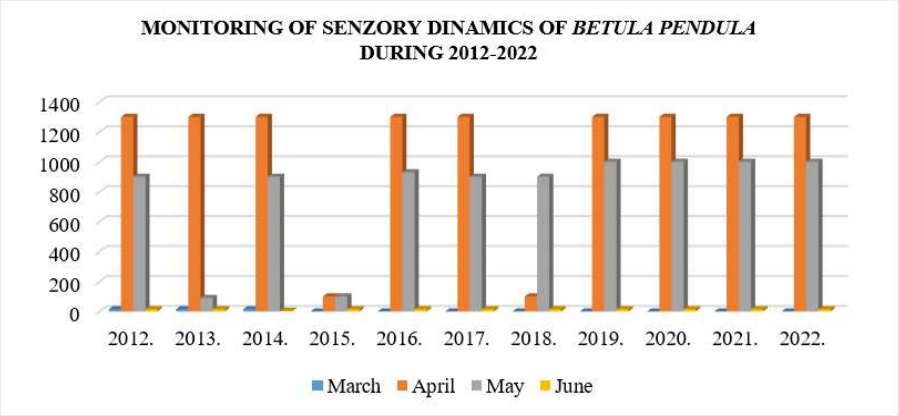

Figure 4. Monitoring of airpollutants for birch trees (*Betula Pendula*) in the air of the urban ecosystem for the observed period 2012-2022.

[3] Source: NAB Scale (National Allergy Bureau of the American Academy of Allergy, Asthma & Immunology), Pollen Rating Scale (PRS) - Forsyth County Environmental Affairs Department

During the ten-year follow-up period (2012-2022) birch (*Betula Pendula*) pollen concentrations were recorded from mid-March to mid-June. The highest concentrations were recorded in April and the first half of May, and the lowest were in March and June. There were no recorded pollen concentrations in July 2012-2022 and partially March 2015-2022. Very high pollen concentrations (>1500grains/m^3) were not recorded. High pollen concentrations (91-1500grains/m^3) were recorded in April 2012-2022 and May 2012 and 2014-2022. Moderate pollen concentrations (16-90grains/m^3) were recorded in May 2013, while low pollen concentrations (1-15grains/m^3) were recorded in March 2012-2014 and June 2012-2022.

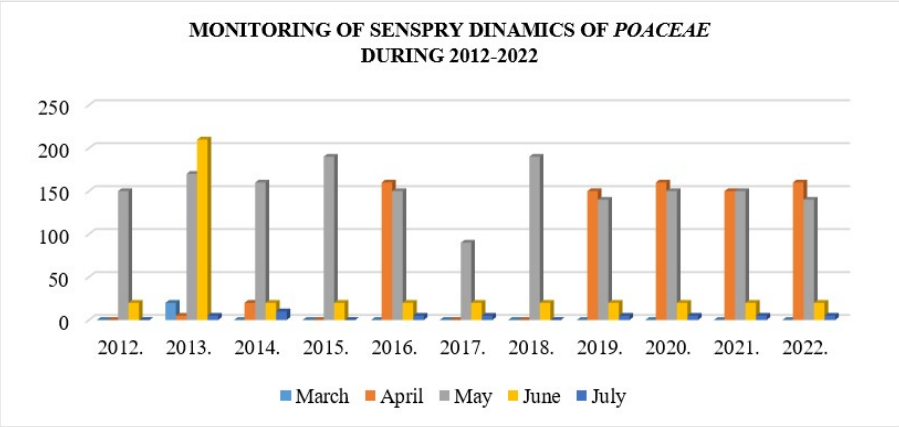

Figure 5. Monitoring of airpollutants for grasses (*Poaceae*) in the air of the urban ecosystem for the observed period 2012-2022.

During the follow-up period (2012-2022) grasses (*Poaceae*) pollen concentrations were no recorded in March (2012 and 2014-2022) and July (2012 and 2015). Very high pollen concentrations (>200grains/m^3) were recorded in June 2013. High pollen concentrations (21-200grains/m^3) were recorded in April 2016 and 2019-2022 and May 2012-2022. Moderate pollen concentrations (6-20grains/m^3) were recorded in March (2013), April (2014), June (2012 and 2014-2022) and July (2014 only). Low pollen concentrations (1-5grains/m^3) were mostly recorded in July (2013 and 2016-2022).

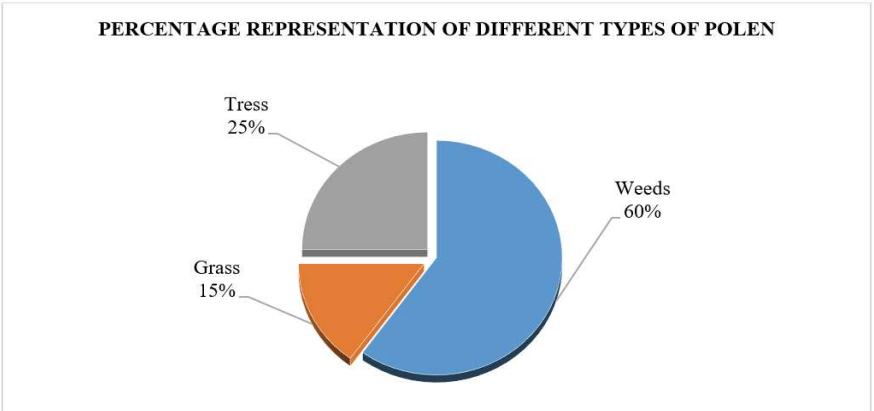

Figure 6. Mean percentage of different pollen types in the air of the urban ecosystem for the observed period 2012-2022.

During the follow-up period, the total prevalence of tree pollen (*Betula Pendula*) and grasses (*Poaceae*) was 40% compared to other weeds 60%. In the period of high concentrations, the preventive measure of protection was increased, but so did the demand for anti-allergic drugs.

In general, the measurements showed that mainly high pollen concentrations of birch (*Betula Pendula*) and grass (*Poaceae*) were in the period of pollution - the strongest effect of outdoor allergens (environmental factors), i.e. during pollination of plants (natural factor).

For birch tree it is the period April - May (first half), while for grasses it is the period April (second half), May and June. However, the cause of pollen pollution (outdoor allergen) due to ill-considered planning of which plant species to cultivate in green city spaces is also man (anthropogenic factor). Similar research, but on weeds (*Ambrosia artetisiifolia L.*), which were conducted in 2012 and 2021, also found that the most common transmission factors were natural factors (favourable climatic conditions) and anthropogenic factors (man) [13, 14].

5. Conclusions

During the ten-year follow-up period, pollen concentrations of *Betula Pendula* and *Poaceae* were registered at the time of their pollution (pollination).

The highest pollen concentrations (X=91-1500 grains/m^3) of *Betula Pendula* were registered in April and May (first half), while of *Poaceae* they were registered in June (X_{Jun}>200 grains/m^3), May and April ($X_{April,May}$=21-200 grains/m^3).

During the follow-up period, the prevalence of *Betula pendule* and *Poaceae* pollen was 40% compared to other weeds 60%.

Due to high concentrations of pollen of these plant species and the seriousness of the problem due to the occurrence of allergic diseases, it is necessary to implement various protection measures in addition to monitoring. Necessary protection measures should be based on education about allergenic plants, thoughtful planning of allergenic plants in urban ecosystems, preventive measures (avoidance of allergens), legal measures and more.

Each individual should apply some of the preventive measures, as well as advice such as: regularly track the pollen forecasts and the pollen calendar, not to be exposed to high concentrations of allergenic plants in lush vegetation areas, especially in the morning hours, not to go out during dry winds outside, regularly vacuum around the house, shower often, especially during pollination periods, wear glasses and a protective mask when going out, take anti-allergy medicine and more.

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Antioxidant properties of juice the green grass of the cereal spelled *(Triticum aestivum ssp. Spelt)*

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Abstract. Spelled (*Triticum aestivum ssp. Spelt*) is one of the older subspecies of modern bread wheat (*Triticum aestivum*). Until the middle of the 20th century, spelled was a very important weed in the world, which was no longer cultivated due to the spread of non-weed forms with higher yields. In recent times, thanks to its qualitative characteristics, this wheat is starting to be cultivated again, because it is considered a "healthier" and "more natural" grain than modern wheat. It is suitable for ecological cultivation because it doesn't require the use of pesticides. Compared to other types of wheat, it has an increased protein content and contains some minerals, including selenium and zinc, as well as a high proportion of fiber. In addition, it contains various bioactive compounds that can contribute to its antioxidant capacity, such as the components carotenoids, tocopherols, tocotrienols, phenolic acids, phytic acid, phytosterols and flavonoids. Wheat grass spelled (aerial parts of wheat) contain concentrated liquid nutrients that can be used as a home phytotherapeutic preparation or distributed commercially as frozen juice or powdered and frozen. It is used to strengthen the immune system, and it also shows anti-cancer effects. The paper investigated the antioxidant effect of juice squeezed from spelled grass (*Triticum aestivum ssp. Spelt*) harvested in the jointing stage. A certain amount of juice was extracted, and the method used to prepare the extract was ultrasonic extraction and maceration. In the extraction of biologically active substances, two solvents were used: distilled water and ethanol. The results showed that the antioxidant activity of the water extract is significantly higher than the ethanol extract.

1. Introduction

Wheat (*Triticum aestivum L.*) is an annual plant from the grass genus (*Triticum*) that belongs to the Poaceae family and is an important component of the human diet. Wheatgrass juice is believed to possess maximum therapeutic qualities in its fresh state and is therefore recommended to be consumed immediately after extraction [1]. The main clinical utility of wheatgrass juice is due to its antioxidant activity resulting from its high content of bioflavonoids such as apigenin, quercetin and luteolin. Other compounds present that make this herb therapeutically effective are indole compounds, apigenin and laetrile [2]. Phenolic compounds are compounds that contain one or more aromatic rings to which one

or more hydroxyl groups are attached [3], and accumulate in vacuoles in the form of glycosides or sugar esters. [4]. Wheatgrass juice has high concentrations of chlorophyll, the most important compounds on earth due to its significant role in the absorption and transmission of light energy in photosynthesis [5], proven responsible for inhibiting the metabolic activation of carcinogens [6-7], also reducing the need for blood building drugs and bone marrow during chemotherapy in breast cancer patients [8]. It is considered a complete food because it contains all amino acids, vitamins and minerals (some only in trace amounts) necessary for human nutrition. Wheatgrass juice is immediately absorbed into the bloodstream and provides instant energy and is the richest source of vitamins A, B, C, E and K, calcium, potassium, iron, magnesium, sodium, sulfur and 17 forms of amino acids [9].

Wheatgrass is thought to help blood flow, digestion and general detoxification of the body due to the presence of biologically active compounds and minerals in it and due to its antioxidant potential resulting from its high content of bioflavonoids. Wheatgrass juice is known as "green blood" which contains a large amount of chlorophyll (70% of the total chemical constituents). The only difference is that the central element in chlorophyll is magnesium, and in hemoglobin it is iron [10]. From published studies, it has been proven that the molecules of human blood hemoglobin and wheat grass chlorophyll contain the same structure and can act as a substitute for hemoglobin in hemoglobin deficiency states. Pharmacologically, wheatgrass has properties such as antidiabetic, antiallergic, antiulcer, hepatoprotective, cardioprotective, antiinflammatory [11], anticancer [12-13], antiulcer [14], antiinflammatory [15], antioxidant [16], antiarthritic [17], antimicrobial activity [18] and low-density lipoprotein lowering effect [19].

2. Materials and methods

Wheat seeds (*Triticum aestivum L.)* were procured and washed with tap water and soaked overnight in tap water. The grain was evenly distributed in pots for germination on peat composed of organic and mineral substances. The seeds have been watered with tap water for twelve days. On the 12th day, swathing was done. Wheat grass blades were cut off at the base, and juice was prepared from them using a juicer.

Wheatgrass juice was subjected to UV extraction and maceration techniques at room temperature with distilled water and ethanol as solvent. Classic maceration extraction was performed at room temperature for 24 hours. After the extraction, vacuum filtration was carried out on a Büchner funnel. Ultrasonic extraction (WiseClean WUC) took 30 minutes. All obtained extracts were stored in a refrigerator at +4°C until further analysis.

The recommended methods of the Association of Official Analytical Chemists were used for the determination of the chemical composition (moisture, ash, lipids and nitrogen content) of obtained extracts [20-24]. At least three replicate determinations were made for each sample. Proteins were calculated by multiplying the sample's percentage nitrogen content by a factor of 6.25. Available carbohydrates were calculated by subtracting the total sum of moisture, proteins, lipids and ash from a 100% sample. Total energy values were calculated in kJ by multiplying the amounts of fat by the factor 37 and protein and carbohydrate by the factor 17 [25].

The content of chloroplast pigments (chlorophyll a, chlorophyll b and carotenoids) was determined by the spectrophotometric method according to Holm and Wettstein [26-27]. 100 □l of wheatgrass juice was weighed on an analytical balance into a 15 mL screw-cap plastic tube. A little MgCO3 powder (on the tip of a knife) was added to the test tube to neutralize the acidity and 990 □l of acetone. The samples were homogenized on a vortex mixer, and then centrifuged at 14,000 rpm for 10 min. The supernatants were pipetted into the cuvette with an automatic pipette and the absorbance of the samples was measured using a photoLlab 6600 UVVIS WTW spectrophotometer at wavelengths of 662, 644 and 440 nm, with acetone as a blank. The obtained absorption values (A662, A644 and A440) were included in the Holm-Wetsttein equations for calculating the concentration of pigments in mg/dm^{-3}, namely chlorophyll a, chlorophyll b, total chlorophyll and carotenoids:

$$\text{Chlorophyll a} = 9{,}784 \times A662 - 0{,}990 \times A644$$

Chlorophyll b = 21,426 x A644 – 4,65 x A662
Clorophyll a+b = 5,134 x A662 + 20,436 x A644
Carotenoids = 4,695 x A440 – 0,268 x (clorophyll a+b)

The obtained values were recalculated and expressed as mg/g of St. T. taking into account the weight of the sample and the dilution.

In the prepared samples, total phenols were determined by the Folin-Ciocalteu method [28], and the results were calculated from the calibration curve of gallic acid. The concentration of total phenols is calculated according to the equation of direction obtained by Excel, with gallic acid concentrations (mg/L) plotted on the abscissa and absorbance values measured on the photoLlab 6600 UVVIS WTW spectrophotometer at 765 nm. A modified colorimetric method with AlCl3 was used to determine total flavonoids [29] and a standard quercetin solution was used to construct the calibration direction.

The DPPH method was used to determine antioxidant capacity. DPPH (2, 2-diphenyl-1-picrylhydrazyl) is one of the most stable organic nitrogen radicals with maximum absorption in UV-VIS at 517 nm. The DPPH radical is a stable nitrogen radical whose solution is dark purple, and with the addition of antioxidants the solution fades as the free radical is reduced to light yellow diphenylpicrylhydrazine, which is monitored spectrophotometrically via a drop in absorbance at 517 nm. The sample was incubated for 15 minutes at 37 °C in the dark. Decreases in absorbance at 517 nm were measured using a spectrophotometer compared to a blank containing methanol. The standard curve was constructed with a Trolox concentration between 0.005 and 1.0 mM [30].

FRAP test: 0.1 ml of test extracts were added to 3 ml of FRAP reagent (0.3 M) acetate buffer, 10 mM 2,4,6- tripyridyl-s-triazine (TPTZ), 20 mM $FeCl_3 \times 6H_2O$ (10: 1: 1, v/v/v) and allowed to stand for 10 min at 37 °C in the dark. Absorbance was measured at 593 nm [31].

3. Results and discussion

The results of the nutrients content and estimated energy values obtained for the 6 samples of *Triticum spelta L.* young leaves extracts are presented in Table 1.

Table 1. Nutritional composition of juice from the green grass of the cereal spelled (*Triticum aestivum ssp. Spelt*).

Sample	Dry matter %	Ash %	Fat %	Protein %	Total carbohydrate %	Energy value kJ /100 g
1	5.87	0.88	0.29	2.12	2.58	90.63
2	6.16	0.69	0.32	2.56	2.59	99.39
2	6.21	0.84	0.30	2.65	2.42	97.29
4	5.84	0.75	0.24	2.73	1.76	85.21
5	5.98	0.79	0.26	2.50	2.43	93.43
6	5.99	0.76	0.18	2.43	2.62	92.51
Average	6.01	0.79	0.26	2.45	2.51	93.94

Previous research shows that the total yield of extracted substances, the content of total phenols, flavonoids and antioxidant activity depend on the applied extraction technique and solvent [32]. In this work, we used distilled water and ethanol as the extraction solvent. The results of testing the antioxidant activity extracts of of juice from the green grass of the cereal spelled (*Triticum aestivum ssp. Spelt*) indicate that this plant is rich in compounds that have antioxidant activity. Due to its distinct nutritional values, today there is an increasing number of scientific research aimed at the popularization and implementation of this supplement in the daily diet of people. Tugba et al. (2014) conducted the research and found that Ferulic acid is the dominant phenolic acid in all wheat grass samples (74-87 mg/100 g), which accounts for 69% of the total acids [33].

Based on the estimated nutrient composition, energy value 100 g of fresh extract of young spelled grass was calculated. Average the value of the extract on the twelfth day was 93.3 kJ/ 100 g. In the

research by Jančić et al., (2022) the average value of the extract on the ninth day was 93.3 kJ/100 g, which was about 15% more than in the extracts obtained in the remaining two days of harvest, our values for the twelfth day were approximately the same with their values on the ninth day [34].

Table 2. Content of chlorophyll a (Kl a), chlorophyll b (Kl b), chlorophyll a + b (Kl a + b), carotenoids (Kar), in wheat grass juice (mg/g).

Sample	Kl a	Kl b	Kl a + b	Kar
1	0.27	0.13	0.40	0.06
2	0.30	0.16	0.46	0.11
3	0.21	0.11	0.32	0.07
4	0.23	0.12	0.35	0.09
Average	0.25	0.13	0.38	0.08

Table 3. Total content of phenols, flavonoids and antioxidant activity of the extract of juice from the green grass of the cereal spelled (*Triticum aestivum ssp. Spelled*) measured by DPPH and FRAP method, obtained by UV extraction and maceration techniques.

			Antioxidant activity	
	Total phenols	Flavonoids	DPPH	FRAP
Sample	±SD	±SD	±SD	±SD
MH_2O	90.05 ± 1.3	73.71 ± 1.3	656.1 ± 3.3	101.5 ± 2.7
MEtOH	51.87 ± 0.9	22.75 ± 0.9	416.8 ± 2.8	82.5 ± 3.3
UVH_2O	99.51 ± 1.7	80.91 ± 1.6	732.8 ± 4.2	117.2 ± 3.1
UVEtOH	56.73 ± 1.5	25.11 ± 1.2	469.6 ± 2.9	94.9 ± 2.4

SD = mean value of 6 measurements ± standard error, MH2O = sample extraction by maceration at room temperature with distilled water, MEtOH = sample extraction by maceration at room temperature with ethanol, UVH2O = ultrasonic extraction with distilled water, UVEtOH = ultrasonic extraction with ethanol, Total phenols (mg GAE/g fresh sample), Flavonoids (mg Quercetin/g fresh sample), The results of both antioxidant methods are expressed as (μM TE/g fresh sample).

Chlorophyll a and chlorophyll b are the predominant forms of chlorophyll in higher plants. Shirude Anup Astok et al. (2011) found that water-soluble chlorophyll extract values show higher values than alcohol extract values. The reason for this is that the chlorophyll content in wheatgrass juice is about 70% and it is soluble in water [35].

The highest content of phenols in wheatgrass juice was determined during UV extraction with distilled water (99.51 ± 1.7 mg GAE/g fresh sample), while, compared to all tested extractions and solvents, the lowest content was determined during extraction by maceration at room temperature with ethanol as solvent (51.87 ± 0.9 mg GAE/g fresh sample). According to Jančić et al., (2022) the concentration of polyphenols in ethanol and water extracts is the highest in grass harvested on the ninth day, and amounts to 61.5 and 107.1 mg GAE/g of fresh sample, respectively. Their obtained results for total phenols were about 50% higher than those reported in the literature for wheat grass [36], while in our case this percentage was slightly lower, about 43%. The results obtained in our study for DPPH and FRAP tests were significantly lower than those obtained in the same studies on fresh wheatgrass juice [36], and slightly higher than those obtained in the same studies on fresh wheatgrass juice samples [37].

4. Conclusion

This study is a study that offers information on the nutritional composition, pigments, phenolic, flavonoid and antioxidant activity of the extract of juice from the green grass of the cereal spelled (*Triticum aestivum ssp. Spelled*). Wheatgrass has been confirmed to be an important source of polyphenols. Antioxidant activity is a very important indicator of the nutritional value of a food, especially from the aspect of a positive effect on human health through the neutralization of harmful

radicals that are released in cellular processes. Therefore, it is necessary to direct further research into the nutritional quality of wheat grass juice (*Triticum aestivum ssp. Spelled*) from other tests for the values of antioxidant activity to the content of vitamins, minerals and other nutrients, and the influence of the preparation and freezing procedures and storage on the quality of juice from the green grass of the cereal spelled (*Triticum aestivum ssp. Spelled*).

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Significance and Role of CE Marking of Construction Products Windows and Doors on the European Union Market

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Abstract. The basic characteristic of the single market of the European Union is the free movement of people, capital, goods and services, but also the fact that products placed on the market must meet the basic requirements of health, safety and consumer protection and environmental protection. Regulation on construction products No. 305/2011 defines the conditions for the placement of construction products on the internal market of the European Union, as well as the methods and systems of conformity assessment for proving the continuity of the properties of construction products. This paper presents the importance and role of CE marking of construction products, windows and doors, which are placed on the market of the European Union.

1. Introduction

The Construction Products Regulation (CPR) 305/2011 is the main EU regulation covering the placing of construction products on the European Union market. CPR and CE marking are focused primarily on the relationship between the manufacturer and the market surveillance authority. They do not directly cover the relationship between producer and buyer. CE marking is a means of enabling products to be placed on the market (offered for sale) within the European Union, on the basis that they have met the regulatory requirements that apply to them [1].

The CE mark (in French Conformite Europeenne-European Conformity) is not a quality mark, but indicates that the product is safe for use, if used as intended.

The Regulation identifies two types of technical specifications that can be used to obtain the CE mark. Product standards are divided into two types: harmonized and non-harmonized standards. Harmonized European standards cover most products, while European technical evaluations deal with products outside the scope of the harmonized standard. In order for a product to receive the CE mark under the Regulation, the manufacturer must comply with a harmonized European standard for the product, if such exists. Non-harmonized product standards are standards that cover products or materials but do not lead to CE marking [1].

Standard EN 14351-1 Windows and doors - Product standard, performance characteristics - Part 1: Windows and external doors for pedestrians, is a standard that identifies independent performance characteristics of materials, except fire resistance and smoke control characteristics, which are applicable to windows, external pedestrian doors and screens. The standard prescribes mandatory information related to handling, installation, maintenance and care, and prescribes the assessment of

compliance of windows and exterior doors with the requirements of this standard, as well as product labeling and marking [5].

2. Conformity assessment

As part of the conformity assessment, the manufacturer must create a product technical file, with which the product compliance with regulatory requirements is proved. The technical file of the window and door product should contain the following chapters of the technical documentation:

- Legislation and standards that apply to the product,
- Product description/product family,
- Data related to the safety of raw materials, materials and components,
- Instructions for use, maintenance and assembly of the product,
- product drawings,
- Initial type examination (product test reports),
- Calculations
- Documentation of the factory production control system,
- Declaration of performance, and
- Label/sticker/label with CE mark.

Conformity assessment is performed by defining the values of a list of characteristics (properties) called "essential characteristics". Product compliance with regulatory requirements with specified values (including classes) must be demonstrated through:

- Initial Type Testing (ITT). Initial type testing is a complete set of tests or other procedures, related to the characteristics to be evaluated, determining the characteristics of the product samples representative of the product type;
- Factory Production Control (FPC). It is a set of procedures that the manufacturer must establish, document, maintain and implement in order to ensure that the product placed on the market has the same characteristics as that of the initial type test, meets regulatory requirements and complies with the specified and declared values defined in the technical documentation.

2.1. Initial Type Testing (ITT)

Initial type testing is a complete set of tests or other procedures, related to the characteristics to be evaluated, determining the characteristics of the product samples representative of the product type. The characteristics for which the manufacturer states a value must be subjected to ITT by means of tests and/or calculations and/or tabulated values in accordance with the EN standard 14351-1:2006+A2:2016.

When using components which characteristics have already been determined by their manufacturers, e.g. radiation properties of the Insulating Glass Unit (IGU), based on compliance with other technical specifications, these characteristics do not need to be re-evaluated provided that the properties of the components and the evaluation method remain the same, that the characteristics of the components correspond to the end use of the final product and the production process does not adversely affect certain characteristics.

If there are changes in product design, raw material, component suppliers, or production processes that would significantly affect one or more characteristics, the type examination must be repeated for certain characteristics. The results of each test must be recorded in a test report. The test report must comply with the relevant clauses of the technical specifications. A complete set of reports, which are related to the product, must be kept by the manufacturer for as long as the product is manufactured, plus a minimum of 10 years [2].

2.1.1. Cascaded ITT and conditions for using the designer's ITT results. The assembly designer (profile manufacturer) can submit an "assembled product", using components produced by him or another manufacturer, for initial type testing by a third party in accordance with the performance characteristics specified and then provide the ITT report to the assemblers, e.g. to the actual manufacturer of the product placed on the market.

In this case, the assembly designer can make the ITT report available to the manufacturers who assemble the product by "cascading" the corresponding report. The manufacturer assembling the components, where some of them are manufactured by other manufacturers, must take into account the concept of "cascaded ITT" in relation to the ITT report prepared on the basis of the tests carried out by the notified body, when declaring the property of the product for which he is responsible for placing it on the market under the following conditions [2]:

- the manufacturer has an contract with the designer for the use of test results and accompanying documentation;
- the manufacturer (installer) must be responsible for placing the product on the market, and must also be responsible for the correct assembly of the product in accordance with the assembly instructions issued by the assembly designer or another body appointed by him that provides assembly instructions;
- the designer's assembly instructions for component assembly must be an integral part of the manufacturer's FPC (Factory Production Control) system;
- the manufacturer (installer) must be able to provide documented evidence that the combination of components he uses and his production processes correspond to the product that was the subject of the ITT;
- the manufacturer (installer) must keep a copy of the test report containing the ITT for 10 years after the end of production;
- regardless of any kind of liability under the agreement/contract signed with the designer of the assembly, the manufacturer (installer) must remain responsible for the product and its compliance with all statements of performance in accordance with this document.

2.2. Factory Production Control (FPC)

The manufacturer must establish, document, maintain and implement a Factory Production Control (FPC) system, in order to ensure that the product placed on the market meets the requirements of the EN 14351-1:2006+A2:2016 standard and complies with the specified and declared values defined by technical documentation. The factory production control system must define the competences, authorizations and responsibilities of the staff involved in the factory control system. The factory production control system consists of the factory production control manual, procedures, instructions and other elements explaining the receipt of incoming raw materials, the production process, control during the production process, as well as the control of finished products [2].

The manufacturer that has established and implemented quality management system in accordance with the ISO 9001:2015 standard and takes into account the specific requirements of the product standard EN 14351-1:2006+A2:2016 meets the requirements of the factory production control system.

Within the framework of the factory production control system, the manufacturer must determine/establish the inspection/control of equipment of basic raw materials, other input components of the production process as well as finished products. The frequency of these inspections is defined in such a way as to ensure permanent compliance with the specified requirements.

The customer's complaint about the delivered product as well as the test results during the factory production control may indicate that it does not comply with the specified requirements. The manufacturer must take all necessary measures to eliminate non-conformities. These measures must be documented and show whether the final product is acceptable or unsatisfactory (rejected) or can be declassified (placed on the market in a lower class). The procedure that deals with product non-conformities and complaints related to specified properties as well as the corrective measures taken to eliminate the non-conformities must be documented [2, 3].

3. Declaration of performance

After the conformity assessment procedure has been carried out, the manufacturer must draw up a declaration of performance. The model of the declaration of performance is given in the Regulation on construction products no. 305/2011. An example of the declaration of performance for window is shown in Figure 1.

Declaration of performance No. 2023/08/01/001		
1. Unique identification code of the product type:		*Window; 4/12/4/12/4; Ug=0.8; Rw=32(-1;-4)*
2. Intended use/uses:		*Windows for residental and non-residental buildings*
3. Manufacturer:		*Company, Address, City, State*
4. Authorized representative:		-
5. System/Systems for assessment and verification of constancy of properties:		*3*
6. Harmonized standard:		*EN 14351-1:2006+A2:2016*
7. Notified body:		
8. Declared performance/performances:		
Essential characteristic	Declared performances	Harmonized standard/Technical Specifications
8.1. Watertightness	9A	EN 14351-1:2006+A2:2016
8.2. Dangerous substances	No	
8.3. Resistance to wind load	C5	
8.4. Impact resistance	NPD	
8.5. Load capacity of safety devices	NPD	
8.6. Acoustic performance Rw (dB)	34 (-2,-6)	
8.7. Thermal transmittance Uw (W/(m²K)	1,0	
8.8. Radiation properties		
8.8.1. Radiation properties - Solar factor (g)	NPD	
8.8.2. Radiation properties – Light transmittance (Tv)	NPD	
8.9. Air permeability	4	
The performance of the product identified above is in conformity with the set of declared performance/s. This declaration of performance is issued, in accordance with Regulation (EU) No. 305/2011, under the sole responsibility of the manufacturer identified above. Signed for and on behalf of the manufacturer: Name and surname: Place: Date: Signature:		

Figure 1. Example of the declaration of performance.

The declaration of performance is issued for each delivery, and it is mandatory to be with other accompanying documents. The declaration of performance is made in the language of the country of export.

4. CE Marking

The manufacturer or his authorized representative is responsible for placing the CE mark on the product after drawing up the declaration of performance. Placing the CE mark must comply with Directive 93/68/EEC. The CE marking symbol must be accompanied by the following information:

- name and registered address or identification mark of the producer;
- the last two digits of the year in which the marking symbol was assigned;
- reference to the European standard;
- product description (generic name, material, dimensions, intended use), and
- information on the essential characteristics of the product.

Figure 2 gives an example of information related to the product, which is provided on the accompanying label, on the package or on the accompanying commercial documents.

CE		*The CE marking consists of the CE marking symbol given in Directive 93/68/EEC.*
NAME OF THE MANUFACTURER, Address, city, state 15		*Manufacturer's name and address* *The last two digits of the year, when the CE mark was placed.*
EN 14351-1:2006+A2:2016		*The number of the harmonized European standard with the year of issue.*
Single-paned window 88MD 4/12/4/12/4; Ug=0.8; Rw=32(-1;-4)		*Product description*
Watertightness:	9A	
Dangerous substances:	No	
Resistance to wind load:	C5	
Impact resistance:	NPD	
Acoustic performance - Rw (dB):	34(-2,-6)	*Information on essential characteristics.*
Thermal transmittance - Uw (W/(m²K):	1,0	
Radiation properties		
Radiation properties - Solar factor (g)	NPD	
Radiation properties – Light transmittance (Tv)	NPD	
Air permeability:	4	

Figure 2. Example of CE marking information .

The CE marking and any accompanying information must be placed in a visible, legible and indelible place in one or more of the following locations:

- any convenient part of the product itself, provided that visibility is ensured when the sashes, frames or panes are open;
- to the added label;
- on its packaging,
- on accompanying commercial documents (eg delivery note) or the manufacturer's published technical specifications.

If the CE mark is reduced or enlarged, the proportions must be respected. Where the applicable directive does not impose specific dimensions, the CE marking must be at least 5 mm high.

There are two main benefits CE marking brings to businesses and consumers:

- businesses know that products bearing the CE marking can be traded in the European Economic Area
- consumers enjoy the same level of health, safety and environmental protection [7].

Not all products must have CE marking. It is compulsory only for most of the products covered by the New Approach Directives. It is forbidden to affix CE marking to other products [7].

5. Conclusion

It is important to know that CE marking is a "passport" for the export of construction products to the European Union and other regional markets that follow the same principles. Before affixing the CE mark, manufacturers must identify potential markets and confirm that their products will meet their needs. The affixed CE mark is not a mark of product quality, but rather a sign of compliance with market regulatory requirements. Regulatory requirements are always related to the safe use of products, that is, to the elimination or reduction of potential hazards to an acceptable level.

Manufacturers of windows and doors, in addition to the initial type of testing of their products, also have the option of using the so-called "cascade type testing" and system 3 of assessment and verification of constancy of performance systems in order to place the CE mark on the product. The above means that the designer or the manufacturer of the profile has conducted all the necessary tests of the product, and that the test results are handed over to the manufacturer or the installer of windows and doors. In addition to the test report, the manufacturer or assembler must regularly carry out factory production control in order to ensure that the product placed on the market meets the requirements of the standard.

Whether the product is suitable for use in a particular building is something that needs to be decided at a later stage, e.g. by the user of the product. However, whether that product will be accepted depends on a number of other factors such as quality, attractiveness of the product, price, delivery time, marketing, etc.

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Confirmation of laboratory competence

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Abstract. Although accreditation is not an obligatory procedure but represents the fastest way to prove competence and confirm the full implementation of a certain quality system, it has become binding if a laboratory wants to offer its services and ensure trust in its services among its users. In the field of metrology, services provided by metrology laboratories in the fields of scientific and industrial metrology are represented by calibrations and testing procedures in accordance with the implementation of the international standard ISO/IEC 17025 and verification services in the field of legal metrology. In addition to the accreditation procedure, competence in the field of calibration and testing can be confirmed by self-declaration of the implemented quality management system within regional metrology organizations. The method of self-declaration of the quality management system is based on the guidelines of the International Committee for Weights and Measures (CIPM), which operates within the International Organization for Weights and Measures (BIPM) and exclusively refers to the laboratories of national metrology institutes and their designated institutes that are holders of national standards and who are signatories to the Mutual Recognition Agreement (CIPM MRA). This paper explains the procedures and requirements that laboratories go through on their way to prove their competence through a quality management system through accreditation with accreditation bodies and through self-declaration of the quality management system within the framework of regional metrology organizations that are operating under the framework of BIPM.

1. Introduction

There are different ways of confirming the competence of conformity assessment bodies. The most well-known way of confirming competence and fulfillment of the requirements of relevant normative documents is the procedure performed by accreditation bodies. However, in the field of metrology, the national metrology institutes and their appointed holders of national measurement standards (NMI and DI) apply the procedure that is carried out within the framework of the regional metrology organizations (RMO).

This paper describes the procedures for confirming the competences of conformity assessment bodies through accreditation and through the procedure and within the framework of the CIPM MRA (Mutual Recognition Agreement at the International Committee for Weights and Measures), i.e. an example of how it takes place in the RMO.

The paper is based on the experiences of the Institute for Metrology of Bosnia and Herzegovina (further on: IMBiH), which is the National Metrology Institute of Bosnia and Herzegovina and which is responsible for managing the metrology system in Bosnia and Herzegovina. IMBiH is a full member

of the EURAMET regional metrology organization (European Association of National Metrology Institutes) and an associate member of the COMET regional metrology organization (Euro-Asian Cooperation of National Metrology Institutes). By participating in these two RMOs, IMBiH confirmed its competences (confirmed QMS system within the framework of EURAMET), and was additionally accredited by the accreditation body for a certain scope of its activities in the provision of metrology services. IMBiH became a signatory of the CIPM MRA in 2011 and provides its metrology services, represented by the currently 84 CMCs (calibration and measurement capabilities) published in the BIPM KCDB.

2. Accreditation

The role of accreditation is to confirm the competence of the conformity assessment body. Accreditation, as well as the application of a specific standard, is not binding in itself, but today it is unthinkable to carry out certain activities without confirming competence issued by a third independent party. In accordance with the international standard ISO/IEC 17000[1], accreditation is a third-party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks.

Legal entities that want to be accredited and thus demonstrate their competence to service users must implement the requirements of a certain standard. The international standards that are applied in the formal demonstration of conformity assessment bodies are the standards of the ISO/IEC 17000 series, by which most often applied in the field of metrology are:

- ISO/IEC 17025 – for calibration and testing laboratories [2],
- ISO 17034 - for manufacturers of reference materials [3],
- ISO/IEC 17020 – for control bodies in the field of legal metrology [4],
- ISO/IEC 17043 – provision of proficiency testing scheme services [5],
- ISO/IEC 17065 – for bodies providing product, process and service certification services [6].

Essentially, accreditation is a process that aims to demonstrate compliance with specific requirements related to competence, independence, and impartiality [7]. Accreditation is carried out by national accreditation bodies. If the body wants its services to be valid even outside the borders of the country where the certification of competence was carried out by the accreditation body, then it is very important that this accreditation body, for example, in the geographical area of Europe, is a member of the European Accreditation (EA). Members of EA have to be signatories to the EA multilateral agreement MLA [8], by which the signatory members of this agreement undertake to mutually accept the equality of accreditation systems and the reliability of conformity assessment results provided by conformity assessment bodies.

In addition, if the service was provided by a body that was accredited by an accreditation body outside of Europe, then it is necessary to pay attention to the fact that, in that case, the accreditation body is a member of the international organization for accreditation bodies, ILAC. That accreditation body has to be a signatory of the ILAC MRA [9] (agreement on mutual recognition), which recognizes accreditation systems of conformity assessment bodies accredited by members of regional accreditations.

Accreditation bodies must have the requirements of the ISO/IEC 17011 standard [10] implemented, which means that their accreditation system must comply with the specified standard, which refers to general requirements for accreditation bodies that accredit conformity assessment bodies. This standard describes the requirements for the qualification of assessors, whether they are assessors who evaluate general requirements or technical requirements of one of the standards.

Each accreditation body must have an adequate number of qualified staff with appropriate knowledge and skills relevant to the accreditation scheme and the geographical region in which they

operate. Assessors are those who make an accreditation body successful, high-quality and reliable in providing different accreditation schemes.

In the metrology field, there are many standards used for quality management systems, but those that are valid for the recognition of laboratory calibration and measurement capabilities (CMC) refer exclusively to two standards, namely ISO/IEC 17025 and ISO 17034. In addition to the general requirements of the quality management system of the relevant standard, which are assessed by the leading assessors of the accreditation body, the experience and qualifications of the technical assessors or technical expert for the subject field are very important for confirming competences in relation to technical competences and standard requirements.

The minimum experience required for technical assessors is based on knowledge of the requirements of the applicable standard (e.g. for calibration and test laboratories ISO/IEC 17025), and that they know the policies of the accreditation body that engages them, which apply to the stated scope of accreditation [11]. The technical assessor or expert must in particular possess specific knowledge for the technical area covered by accreditation (it may refer to only one part of the laboratory's scope of work or several related areas). This includes the proper execution of relevant calibration or testing methods as well as related external normative documents for performance of the same, evaluation of measurement uncertainty, adequate knowledge of performance and evaluation of interlaboratory comparisons, as well as knowledge of the requirements for ensuring the traceability of the measurement result.

The duration of the accreditation procedure depends on the readiness of the conformity assessment body itself, i.e., whether it has previously met the key requirements of the standards related to adequate participation in intercomparison in accordance with the declared scope, whether the staff of the conformity assessment body is qualified to provide services in accordance with the declared scope, and whether it has ensured the traceability of its working standards. If there are no key nonconformities or administrative obstacles, the conformity assessment body can achieve the status of an accredited laboratory as a competent body for the provision of services in a period of up to six months. The period for which accreditation is issued depends on the individual national accreditation systems, but is not longer than 5 years with regular supervision during the approved period.

3. Confirmation of competences by the RMO

The equivalent procedure of confirming the competence of the conformity assessment body through the accreditation body, i.e. the implementation of the quality management system in accordance with certain standards, is through confirmation in regional metrology organizations (RMO). Regional metrology organizations for their member countries, exclusively for National Metrology Institutes (NMI) and their designated institutes, holder of national standards (DI), carry out a procedure for reviewing their calibration and measurement capabilities (CMC) [12] for the purpose of recognizing competences according to the global Mutual Recognition Arrangement (MRA) [13] of the International Committee of Weights and Measures (CIPM) [14]. All metrology institutes participating in the CIPM MRA must maintain a quality management system in accordance with the aforementioned agreement in order to ensure competences of their calibration and measurement capabilities. Confirmation of the competence of the implemented quality management system takes place through a horizontal technical committee for quality, while successful confirmation of participation in intercomparison takes place through vertical technical committees depending on the metrology field. The official confirmation of competence is concluded by the publication of calibration and measurement capabilities (CMC) in the Key Comparison Database (KCDB) in the International Bureau of Weights and Measures (BIPM), which is described in a separate chapter of this paper. This confirmation of competences is preceded by certain actions that require either evaluation of competences through accreditation or evaluation by an equivalent procedure, i.e. through Peer Review.

The procedure for confirming the competences of conformity assessment bodies in accordance with the ISO/IEC 17025 and ISO 17034 standards differs among the bodies of regional metrology organizations, which can lead to different time duration until the final confirmation of competences. There are six RMOs operating within the world metrology system, while in this paper we will briefly compare the procedures implemented by EURAMET and COOMET.

EURAMET and COOMET, as regional metrology organizations, use written evaluation procedures for the implementation of quality management system within the national metrology infrastructure. The main reference documents used in evaluation process of the quality management system of the above mentioned two regional metrology organizations are:

- 1. EURAMET: G/TCQ/PRC/001 ver. 4.0 from 22.09.2021 [15].
- 2. COOMET: R/AQ/13:2019 from 28.03.2019 [16].

When comparing the procedures described in the mentioned documents, it is easy to see that the COOMET procedure is very similar to the accreditation procedure in accordance with the requirements of ISO/IEC 17025, and in this sense, it can be said that the approach in the COOMET organization is more rigorous in terms of time frame and relations with applicants.

EURAMET recognizes two procedures for evaluating the competence of conformity assessment bodies: self-declaration when Peer Review is carried out by equivalent NMIs or DIs, or recognition of an accreditation certificate issued by a national accreditation body signatory to the ILAC MRA for the reference scope.

In the event that the accreditation certificate is accepted, it is important that during the evaluation, the accreditation body hires personnel from a laboratory that has at least the same technical competence as the laboratory being evaluated, and their names and qualifications must be known to the technical committee for the quality of the subjected RMO.

If the accreditation certificate is accepted, then it is important that the scope of work reported to the RMO is equal to that covered by the accreditation. COOMET does not specify the accreditation procedure in its reference document because COOMET acts independently as an assessment body for all technical areas (within NMI or external DI) that are part of the measurement systems of member states. Although both of the RMO organizations listed here refer to the corresponding CIPM MRA documents when conducting procedures for reviewing and confirming the competences of their NMI/DI members. However these procedures differ in their execution.

Both organizations base their procedures on the written presentation of the QMS of their members (NMI or DI that are the subject of evaluation), followed by the oral presentation of the QMS and the conducted Peer Review. However, the order of these separate activities differs within these two RMOs. Before reviewing and presenting the QMS, EURAMET requires a successful Peer Review for those areas for which the CMC entry will be submitted. At COOMET, the order is different, first, the review of the QMS documentation is performed through a written report, followed by an oral presentation, and finally, a Peer Review is performed.

Unlike EURAMET, in which the subjected NMI or DI can by itself arrange experts (auditors) for Peer Review from other NMIs or DIs with already confirmed competences at the same level that is being applied for (or higher), COOMET forms a commission whose representatives are chosen by the chairman of the technical committee for quality. During the oral presentation in both organizations, all members of the technical committee of the parent RMO have the right to ask questions related to the implementation of the respective standards.

After the QMS has been confirmed, with no further corrective actions or nonconformities identified, confidence in the implemented QMS is confirmed in both organizations for a period of 5 years. With formal confirmation by the relevant technical committee within the RMO, they commit to an ongoing, i.e., permanent, process of monitoring the implemented quality management system. In

those 5 years, both organizations, through their bodies within the technical committees for quality, review and monitor the previously confirmed QMS through the annual reports on the implementation of the QMS delivered by NMI/DI (regular obligation) and indicates if any corrections have to be made in accordance with any identified nonconformities. In their annual reports, NMI and DI list all relevant participation in RMO activities and projects, including comparisons, other expertise and experience, measurement infrastructure, equipment, improvement of measurement capabilities, scientific work, trainings, and consultations with technical experts of other RMOs, i.e., all work that gives an institute credibility and recognition through realized activities, but also experts who are certainly the most important segment of acquired competences.

After 5 years, the process of reviewing the QMS system is repeated as in the case of the initial presentation. Institutes (NMI or DI) are obliged to regularly conduct Peer Reviews for all areas for which they have published CMCs, according to a certain period established by RMO (e.g., every five years), and reports are submitted to the technical committee for Quality in RMO. These Peer Reviews are registered as separate RMO projects. Each RMO is required to report to the JCRB on validated quality management systems, thereby further validating the published CMC. In parallel with this, there are periodic intercomparisons as proof of maintaining the quality of the results and the calibration and measurement capabilities of national measurement standards.

Those NMIs and DIs that are unable to eliminate the identified non-compliances within the defined deadlines are obliged to inform BIPM and gray out their CMCs, i.e., stop providing their services until the QMS implementation is reconfirmed. Due to these differences in the performance of QMS reviews, NMIs and DIs that are members of COOMET need a longer time to confirm their quality management system for the first time (in the best case, a year), while it can be confirmed much faster through EURAMET's implementation of QMS due to the possibility of independently arranging Peer Review.

The process explained above is a process that is implemented within one RMO and represents the CMC review in the frame of the RMO (intra regional review), that is, within the technical committee or TC/WG working group for the technical areas that have been reported. After that, a review is conducted by other RMOs and the JCRB (inter regional review). This process includes the review by all TC/WG Chairs in all RMOs and the approval of the proposed CMC (Shown in Figure 1). In order for this process to be carried out, it is necessary that the results or final reports on intercomparisons to which the CMC are linked have been entered into the international database. The review is also performed by the relevant consultative committee (CC) within the JCRB. The same process is followed by a review of the declared CMC for activities within the framework of the ISO/IEC 17025 standard, as well as a review of the stated CRM implemented within the framework of the ISO 17034 standard. This is an open Peer Review process that takes place through the BIPM web platform, which has been improved with the aim of digitizing the processes run by the BIPM.

The criterion for acceptance of CMCs and their publication in KCDB must be fulfilled and refers to metrological traceability defined by the policy of the CIPM MRA agreement [17]. The measurement traceability of national measurement standards should be realized through the primary implementation of the measurement unit, in which case traceability is declared through a demonstrated implementation of the SI system measurement unit, or through another institute that has a relevant CMC with the appropriate measurement uncertainty published in the KCDB, or through calibrations and measurement services offered by BIPM, in which case measurement traceability is declared through the laboratory that provided the service.

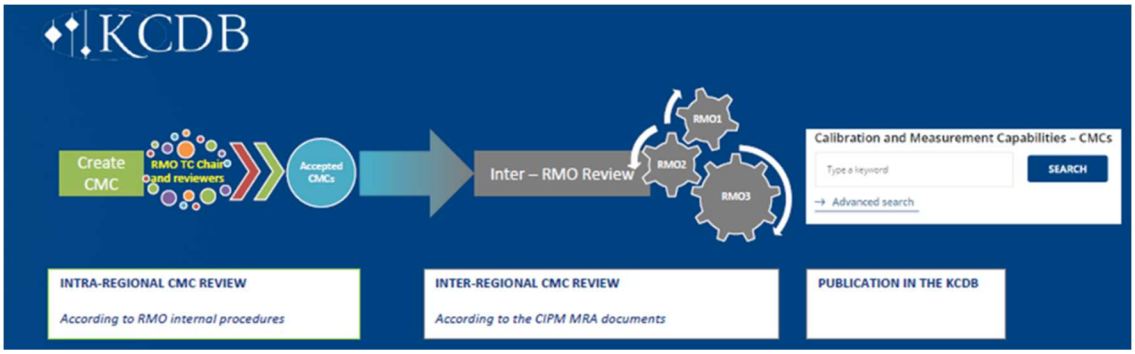

Figure 1. CMC review processes for publication in KCDB (source: bipm.org).

The institute that declares the CMC has the responsibility to declare the CMC in accordance with the achieved results in intercomparisons that support the declared CMC. Further, the institute has the primary responsibility to modify the CMC, temporarily withdraw the CMC (grey out the CMC), or delete the CMC from the KCDB. RMO organizations have the responsibility to monitor the impact of the results of key and additional intercomparisons on the declared CMC for all institutes for which they are in charge, and the consultative committees (CC) are responsible for providing support in organizing new intercomparisons, proposing the scope of intercomparisons, and coordinating the overall review process.

The entire CMC declaration process in KCDB is shown in Figure 2.

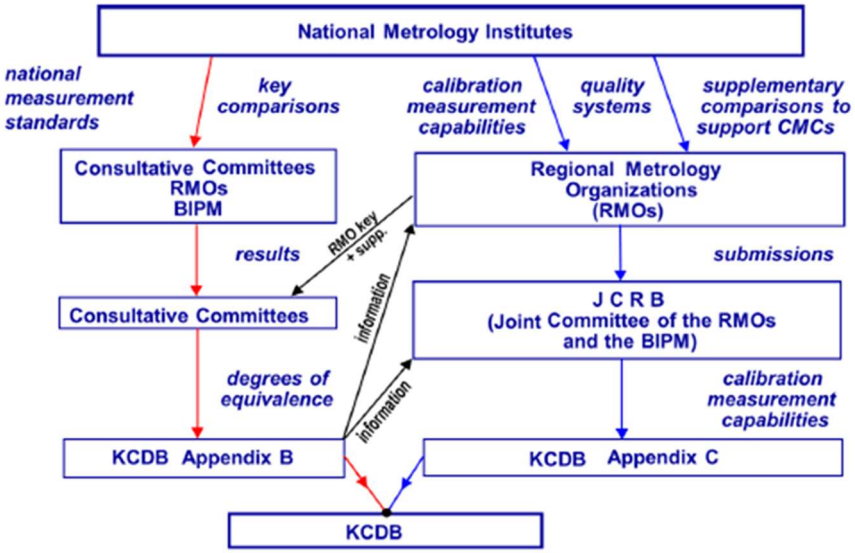

Figure 2. The process of publishing CMC in KCBD.

4. A comparative view of the Accreditation Procedure and Peer Review

As we stated in the process of reviewing technical competences, it is possible to recognize the accredited scope for technical areas that are covered by accreditation or to carry out a review of the self-declared scope for the technical areas for which it has been declared. In practice, as we saw in the previous point, we have different approaches. The policy of individual institutes is to exclusively go through self-declaration and conduct Peer Review within the framework of RMO, while some institutes have a part of the field covered by accreditation and a part covered by self-declaration. A brief overview of how similar the processes are and what they require can be found in figure 3.

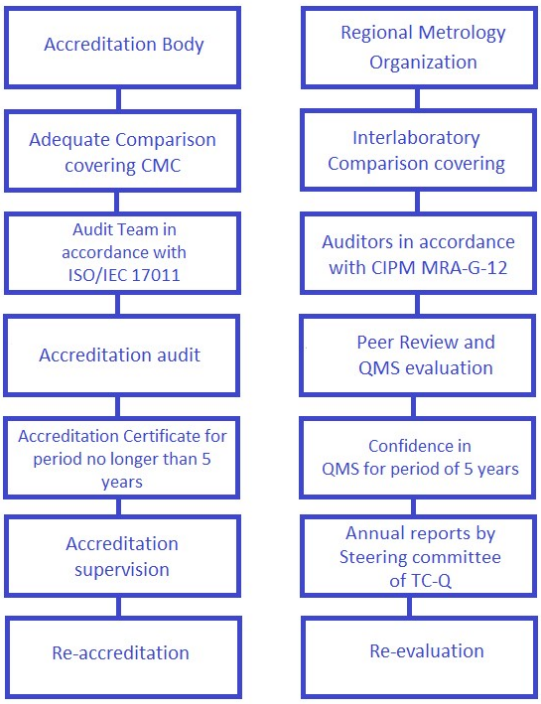

Figure 3. Figure showing comparative view between Accreditation and Peer Review under RMO.

5. Confirmation of competences of National Metrology Institutes through the CIPM MRA procedure

National Metrology Institutes and Designated Institutes holding national measurement standards publish calibration and measurement capabilities (CMC) for national measurement standards in the international Key Comparison Database (KCDB) [18] in BIPM. This procedure is established under the CIPM MRA. The signatories to this agreement are the National Metrology Institutes of member states or associated members of the General Conference on Weights and Measures (CGPM). BIPM is an international organization established by the Treaty of the Meter Convention [19] and has the task of ensuring the worldwide unity of measurements and their metrological traceability to the International System of Units (SI). With all its tasks, BIPM promotes and improves the global comparability of measurements. Within the framework of the CIPM MRA Agreement, all signatory institutes mutually recognize the validity of calibration and measurement certificates for sizes, ranges, and measurement uncertainties reported for state standards in the BIPM KCDB. The CIPM MRA agreement ensures that the confirmed internationally recognized CMCs of the institutes participating in the agreement and the results of key and additional comparisons at the highest scientific level that support the published CMCs are transparently presented in the BIPM KCDB.

The CIPM MRA agreement ensures the comparability and reliability of measurements performed around the world. The CIPM MRA international agreement is at the highest metrology level, demonstrates the international equivalence of national measurement standards of National Metrology Institutes and their CMCs, and ultimately provides governments and other parties with a reliable technical basis for broader agreements. This CIPM MRA agreement provides a significant way to reduce technical barriers to international trade.

The CIPM MRA and ILAC MRA are complementary. The implementation of these agreements helps to ensure confidence in the consistency of the traceability of measurements according to the SI system worldwide. The CIPM MRA agreement is a contract of National Metrology Institutes, and regionally for Europe, it is adequate to the EA MLA Multilateral Agreement between accreditation bodies (EA MLA, European Accreditation Multilateral Agreement). EA MLA facilitates the

movement of goods and services and the removal of technical barriers to trade through the acceptance and creation of confidence in the accreditation of state accreditation bodies and the activities of accredited conformity assessment bodies. This agreement is administered by the European Organization for Cooperation in the Field of Accreditation (EA), appointed by the European Commission, in accordance with Regulation (EC) 765/2008 [20].

All accredited bodies within the scope of the ILAC MRA agreement, including the accreditation bodies that are part of the EA MLA, recognize the CIPM MRA agreement, which is at the highest measurement level, i.e., ensures and documents the traceability of measurements at the highest level. This is defined by the ILAC Policy on Metrological Traceability of Measurement Results [21]. The equivalence of measurements at all levels is presented in Figure 4.

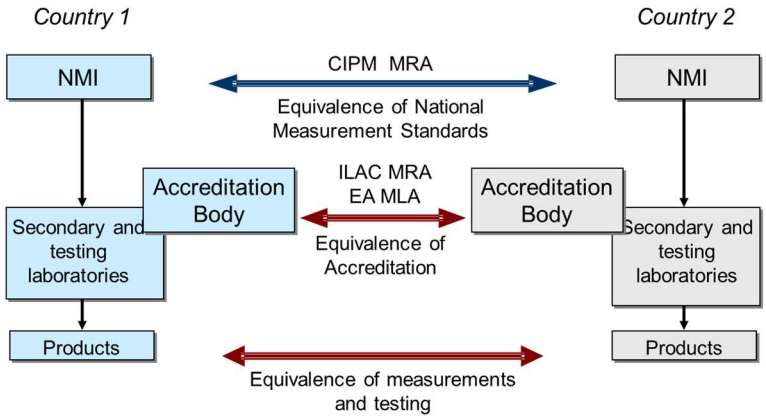

Figure 4. Equivalence of measurements.

International recognition of the declared CMCs by National Metrology Institutes and Designated Institutes (holders of national measurement standards) is carried out in accordance with the following documents:

- Quality Management System in the CIPM MRA guidelines for monitoring and reporting (CIPM MRA-G-12) [22] and
- Calibration and measurement characteristics in the context of the CIPM MRA Guide for their Inspection, Acceptance, and Maintenance (CIPM MRA-G-13) [12].

CIPM MRA requires that participating institutes establish and maintain a Quality Management System (ISO/IEC 17025 and/or ISO 17034), then that Regional Metrology Organizations review and monitor the Quality Management Systems of their members, and that each of the Regional Metrology Organizations report to the Joint Committee of Regional Metrology Organizations and BIPM (JCRB) on their review process and conclusions. A validated Quality Management System is a prerequisite for submitting CMCs for international validation.

The basic technical prerequisite is that NMI successfully participated in a key or supplementary intercomparison that was realized either within the framework of RMO or within the framework of BIPM. RMOs organize key or supplementary comparisons of their member metrology institutes within technical committees (TC) for certain areas of calibration or testing. Also, individual institutes that are part of the consultative committees (CC) in the CIPM can participate directly in key intercomparisons and thus prove their success. All relevant key or supplementary comparisons at the level of RMO or BIPM are realized according to the document according to which intercomparisons are carried out. This document is a measurement comparison within the framework of the CIPM MRA Guidelines for Organization, Participation, and Reporting (CIPM MRA-G-11) [23]. The network of intercomparisons, which includes comparisons from metrology institutes (national or designated), enables the comparability of measurements at the highest metrology level and is documented in the

BIPM KCDB as a key proof of achieved technical competences. BIPM maintains an international database that provides information on key and supplementary comparisons at the CIPM or RMO level that support published CMCs. The initial comparisons within the CIPM are at the global level, while these are followed by the RMO at the regional level. Regional comparisons are linked, i.e., recalculated, through the results of institutes that participate both at the global and regional levels. The following figure presents a network of comparisons and connections between comparisons at different levels.

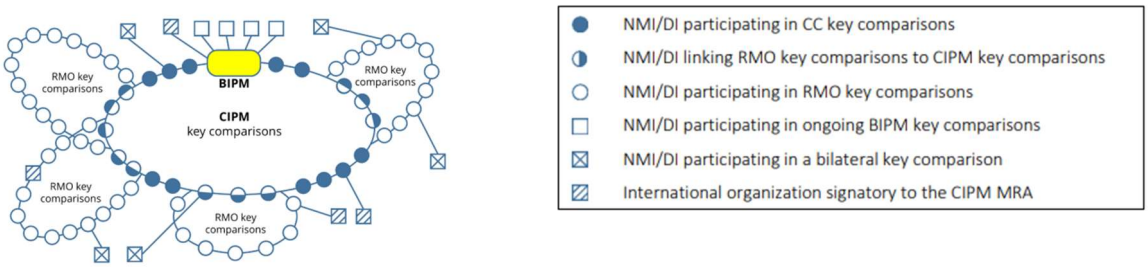

Figure 5. The connections between key comparisons (source: bipm.org).

6. Conclusions

Calibration and measurement capabilities (CMCs) are determined by the measured quantity and the expanded measurement uncertainty (generally given for a confidence level of 95%) for a given scope, method, or instrument used, followed by the values of influential parameters and other relevant information. CMC represents technical possibilities, i.e., services available for users under normal conditions. There are various internationally acceptable processes for confirming the competences of laboratories for the provision of metrology services through accreditation or confirmation within the framework of the RMO for National Metrology Institutes and their holders of national measurement standards (NMI and DI). There are certain differences that are reflected in the sequence of certain activities for confirming the competences of conformity assessment bodies, but those that are most significant are reflected in the length of the process itself, the selection of assessors (auditors), and the final decision on confirming the implementation of the QMS based on the relevant normative documents. Accreditation represents the fastest way to confirm competence, but ultimately everything depends on the readiness of the body to be assessed for compliance and fulfilment of all the necessary requirements. Accreditation, based on the auditor's findings, makes a decision on the status of fulfilment of the requirements for the implementation of the relevant standards. On the other hand, the RMO, in addition to the findings of the assessor (the peer reviewer), includes the opinions of all RMO members who have the right to ask questions related to the fulfilment of the requirements of the relevant standards in the decision-making process. Regardless of whether the conformity assessment body is accredited or not, it must undergo additional checks by the relevant RMO technical committee (TC-Q). According to the complexity of the review procedure, the RMO represents a significantly demanding procedure for confirming the competence of the conformity assessment body.

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Environmental management accounting as a function of socially responsible business

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Abstract. We are witnessing an increasing threat to our planet, which is reflected in the inhumane use of natural resources, the adverse impact of climate change, and inadequate production and consumption. It is precisely this fear for the future that "forces" individuals to awaken their own awareness of environmental protection and potentially prevent or slow down negative impacts on the environment. The company's focus is exclusively on making a profit with as few costs and risks as possible, and social responsibility, which includes environmental protection, is often forgotten. Being socially responsible for a company also requires additional costs arising from certain investments. The aim of this work is to investigate how environmental management accounting affects socially responsible business, and therefore the main objectives to be investigated are: what is environmental management accounting, what does social responsibility mean, what costs arise from environmental care and sustainable development, how a report on social responsibility is being prepared, and an analysis of the socially responsible business of BiH companies.

1. Introduction

Historically speaking, the definition of accounting has changed and supplemented over time. What they have in common is that accounting is one of the most important sectors in any company because it encompasses a set of methods, techniques and skills needed to interpret economic activities. The research problem is focused on how a company can also take care of environmental protection and be socially responsible while achieving maximum profit. The subject of research in this paper is to clarify the link between managerial environmental accounting and corporate social responsibility, that is, how to get from classical accounting to "green" accounting and eco-management. According to the set subject and research problem, we can set the main hypothesis: investigate and prove that companies are increasingly focused on environmental care and that they prepare a report on social responsibility. Caring for the environment requires additional costs for the company and tracking information, so the company should also keep environmental accounting.

2. Accounting of environmental protection

The advancement of technology, which greatly changed the company's development strategy, led to the fact that the management of the company, in addition to the basic rules, must also respect the rules of environmental protection. In other words, when performing the basic activity, the principle of sustainable development and the quality of the future life of civilization should be chosen. We can say that the principle of sustainable development is a phenomenon that advocates meeting the needs of current generations without negatively affecting the needs of future generations.

In addition to classic debt-claim accounting, the need for environmental protection accounting emerged, the main goal of which is environmental protection. In literature and practice, the term "environmental accounting" means "all those areas of accounting that must be adapted to new requirements in the business system, due to its orientation towards environmental protection, down to the lowest level of eco-accounting, i.e. green accounting. [1] As part of environmental accounting, the term "green accounting" is used (Figure 1). It is also called responsibility accounting. The purpose of this accounting is the assessment of the economic effects of the application of relevant regulations, standards, contracts, protocols and other international, European, national and other measures, whose task is to improve and protect the environment, and to save and replace non-renewable and environmentally harmful resources. [2] This accounting primarily emphasizes the tools that will be used to convey information about the use of natural resources and to what extent such operations cause environmental protection costs that will unselfishly, in addition to profits, promote the preservation of non-renewable resources. Managerial accounting for environmental protection deals with the preparation, analysis and use of information that is necessary for eco-management, namely: information on the consumption of energy, water, raw materials and materials, as well as incurred costs and savings in the field of environmental improvement.

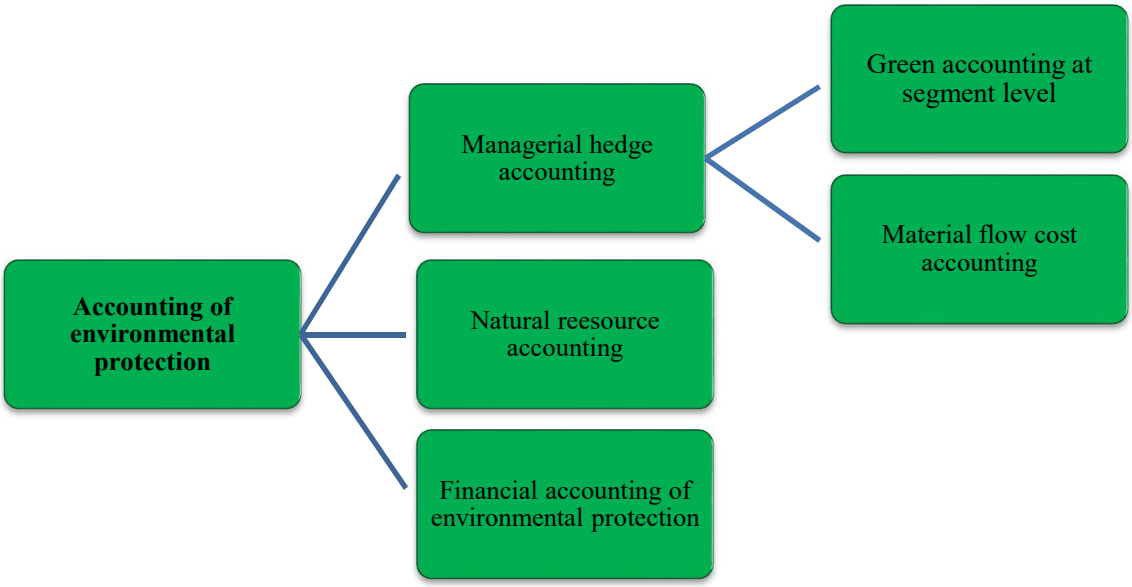

Figure 1. Area of environmental accounting. [2]

2.1. Managerial environmental accounting

According to Kurtanović and Mušinbegović, managerial environmental accounting is defined as the process of identification, collection, calculation, analysis, internal reporting and use of information regarding materials and energy, costs for environmental protection as well as other data related to costs in the decision-making process, in order to adopt appropriate decisions that would contribute to environmental protection. [2] As shown in Figure 1, managerial environmental accounting is a combination of "green" accounting and cost accounting with the support of financial and non-financial information, all with the aim of sustainable development as an essential value for the entire society.

Environmental management accounting also takes into account non-financial information about the use, flows and final fate of energy, water, materials and waste because the use of energy, water and materials along with the generation of waste and emissions is directly related to many organizational activities that affect the environment. [3] Such information is useful for management to make timely business decisions, as well as consideration of possible costs that will arise from various business activities.

2.2. Environmental cost accounting

The costs of environmental protection are the costs of investment in the improvement and protection of the environment, which, observed through financial statements, should leave a short-term and long-term effect on society. In practice, there are several types of costs related to the environment, and they are conditioned by the activity of the company and the hierarchical management structure, so they are considered specific costs. [4]

Environmental protection financing costs are public expenditures intended to protect and improve the quality of the environment [5]. According to measurability, these costs are divided into [2]:

- convection costs
- hidden costs
- unpredictable costs
- costs of relations with interest groups and image costs.

Convection costs include the costs of raw materials and materials, capital, i. e. normal labor costs as well as costs imposed by legislation. The most common hidden costs can be the costs arising from the planning, information, testing, recycling and control phases of operations. On the other hand, there are costs that are not easily measurable and unpredictable, and may appear in the form of penalties and expenses imposed by the state. Costs that are not easily measurable include the costs of relations with interest groups and include the costs of relations with customers, suppliers, employees and the public sector.

According to the accounting monitoring of costs, they can be divided into fixed and variable costs. Fixed costs are certain fees that the company must pay in accordance with environmental protection laws, fees for water protection, fees for disposal of packaging and other waste, depreciation of machines and facilities for collecting, sorting and processing waste, salaries of workers who work on waste management, etc. Variable costs can include the purchase value of raw materials, the costs of purchasing waste material, packaging, etc., the energy required for the operation of plants, plants and machines, fuel costs, costs of selling finished products, etc. [6]

3. Socially responsible business

In this part of the work, the concept of socially responsible business, the dimensions of social responsibility and sustainable development, which are directly related to the protection and care of the environment, are presented. Sustainable development plays a major role in every scientific discipline. The key factors that influence the preservation of the environment are the awareness and education of the population, the development of technology in the direction of ecology, and legal regulations.

Economists narrow and limit sustainable development by reducing economic goals to growth and efficiency, social goals to fair distribution and poverty reduction, and environmental sustainability is sought to be achieved only by managing natural resources. [7] In the modern age, being socially responsible is a challenge for many companies, while at the same time taking care of the environment and fulfilling the mission and vision of one's own business. A successful company is not considered a company that inevitably just makes a profit, but also a company that takes care of a healthy environment, educates employees, participates in various projects, invests in the education of young people, etc. In this way, it raises its business to a high standard and creates a favorable image of business that will have a positive effect on citizens and business actors. [8]

Social responsibility represents "intelligent and objective concern for the well-being of society that limits the behavior of individuals and companies from extremely destructive activities, regardless of how quickly they are profitable, and leads in the direction of positive contributions to the well-being of people, which can be defined in different ways. The goal of social responsibility is to preserve profitability and at the same time enable the creation of high living standards for interest-influential groups inside and outside the company. [9]

3.1. Dimensions of social responsibility

As already stated, socially responsible business focuses on environmental protection and rational consumption of natural resources. However, the development of modern market economies that led to the development of technology and higher costs ultimately resulted in two dimensions of social responsibility, namely the internal and external dimensions. The internal dimension of CSR refers to activities that are undertaken within the company itself, that is, to activities that reflect the well-being of the company's employees. [10] The benefits brought by the application of CSR within the company include better motivation and retention of employees, higher productivity, reduction of absenteeism in the workplace and the introduction of efficient and environmentally accepted production techniques. [9] The internal dimensions of CSR include the management of human resources, health and safety at work, adaptation to changes, management of environmental and natural resource impacts.

Socially responsible business extends beyond the company itself - to the local community and various stakeholders (in addition to employees and shareholders): business partners and suppliers, consumers, public administration, local associations, etc. [11] In addition to the above, respect for human rights and global concern for the environment are considered external dimensions of social responsibility that enhance the business activity of the company and lead to its productivity. [12]

3.2. Socially responsible reporting

Social responsibility reports have become popular recently for large companies. In addition to basic financial information that interest groups, non-financial information regarding social responsibility and sustainable development is also necessary.Non-financial reports provide adequate information about the company's social and environmental performance, and as such serve the company "as an instrument for communicating social responsibility to internal and external interest groups".[13] Based on the report, the company creates indirect communication with the public, providing information about employees, organizational culture, climate and internal values. Very often, companies are promoted in such a way and social responsibility reports are published only for good PR, and they rarely state the shortcomings of their company because the reports are not standardized. It is precisely for this reason that companies should adhere to guidelines for the standardization of such reports so that interested external users can compare results in the same or similar activity. The Global Reporting Initiative (GRI) prescribes guidelines that are today the most important and most widely used standard for sustainability reporting. They aim to advance the harmonization of reporting, ensuring a comprehensive framework for companies that is constantly being improved, in order to ensure the credibility of companies' reporting on their environmental, social and economic performance. [13] The GRI contains:

- guidelines for sustainability reporting refer to the methodology of the content and quality of the report,
- protocols with indicators that include instructions for writing reports,
- sectoral supplements that describe each specific activity,
- technical protocols on specific publication of reports.

4. Analysis of socially responsible business of Bosnia and Herzegovina companies

According to *Husaković* and the research carried out so far in Bosnia and Herzegovina, it was determined that very few companies publish social responsibility reports at all and that they are primarily focused on responsibility towards the market, while the relationship towards employees, society and the environment is neglected. Companies in BiH use this type of report to improve their own image and attract customers and ultimately make a profit. Reports of BiH companies mainly contain information about donations, sponsorships and humanitarian actions with very little information about employees, ecology and sustainable development, suppliers, etc. included. and are not in accordance with the prescribed standards.[14] The biggest challenge for the development of socially responsible business in Bosnia and Herzegovina is the lack of policies, legislation and standards relevant to the concept of CSR in Bosnia and Herzegovina. Companies in Bosnia and Herzegovina generally understand CSR as philanthropy, donations, well-defined employment strategies or business within legal norms. [15]

By analyzing the published reports of BH companies, we saw that the emphasis is placed on responsibility towards the market, while the attitude towards employees, society and the environment is neglected. In addition to the basic financial information that is published in the basic financial reports,

according to the GRI guidelines, companies are also required to publish non-financial information, the so-called social responsibility reports. According to the GRI guidelines [16] the reports of companies published on websites were analyzed. The company Mtel [17], in its report on social responsibility, emphasizes responsibility towards the market, while the relationship towards employees, society and the environment is neglected. Activities related to humanitarian actions and donations aimed at improving the image and attracting customers are listed in detail. It is positive that the Reports have been published since 2010, and that over the years the ecology and care of the environment have gradually been improved through systematic examinations of the level of electric field radiation, management and disposal of waste electrical and electronic equipment, collection and recycling of packaging waste, and saving paper. According to the data from the website for the year 2021, Addiko bank [18] in its annual report includes a chapter on the Analysis of non-financial business indicators related to resource management, socially responsible business and investment in the environment. Strategic management of human resources refers to management of work performance, selection and recruitment, talent development, education and development of employees, and in this way builds one's own image. By conducting educational programs, he improves leadership skills and attitude towards clients. The bank is included in the dual education program, in cooperation with the High School of Economics in Sarajevo, and as of 2021 has 343 employees. Socially responsible business is presented through the development and well-being of children and young people, support for vulnerable social groups and environmental protection. It is mainly about humanitarian actions and donations in schools and hospitals with the aim of improving the quality and living conditions of people.

Investment in the environment is reflected in household use of resources, i.e. water consumption, electricity consumption, paper consumption and recycling, fleet and building management, health and safety at work, digitization, etc.

According to data from the official website of Bh Telecom, it is the leading telecommunications operator in Bosnia and Herzegovina that provides the most modern and high-quality services in the field of mobile, fixed and internet networks. In addition to basic financial data, the report on social responsibility for 2021 also contains non-financial data aimed at socially responsible business.

Socially responsible business is an integral part of BH Telecom's business practice and is continuously demonstrated through various activities, the most important of which are donations to non-profit organizations and supporting sports, cultural, humanitarian and other events through sponsorship arrangements, as well as investing in education and science projects, and others projects that are significant for the development of Bosnia and Herzegovina society. [19] It is similar with the company Bosnalijek. According to the information available on the website, it cites corporate responsibility, which mainly includes philanthropy with a focus on donations and sponsorships, and a section on environmental protection and encouraging education, which look promising in the field of future improvement. [20]

From 2021, companies in Bosnia and Herzegovina are moving towards sustainable development following the global framework for sustainable reporting. The result of this is the project "Support for the preparation for the implementation of the Sustainable Development Goals (SDG) and engagement of the private sector", financed by Sweden, and implemented by the United Nations Development Program in Bosnia and Herzegovina (UNDP in BiH).[21] As part of the project, the first schedule in Bosnia and Herzegovina was created for the preparation of an annual report on sustainable business that follows the Global Reporting Initiative (GRI) standards.

5. Conclusion

The purpose of this work was to explain the importance of quality environmental accounting and its impact on socially responsible business. The advancement of technology, which greatly changed the company's development strategy, led to the fact that the management of the company, in addition to the basic rules, must also respect the rules of environmental protection. Although the goal of every company is profit maximization, it must also satisfy the other party related to sustainable development, the public, investors, employees, etc., and such actions require additional costs. In addition to the basic financial information that is published in the basic financial reports, according to the GRI guidelines, companies are also required to publish non-financial information, the so-called social responsibility reports. Such

reports have become popular for large companies in the world, while companies in Bosnia and Herzegovina have not yet acquired such a practice. Companies also mention social responsibility in their business reports, which mainly include philanthropy with a focus on donations and sponsorships, and a section on environmental protection that looks promising in terms of future improvements.

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Application of the method of artificial regulation of the photoperiod in Pramenka sheep as a measure of sustainable development of sheep breeding in the Una-Sana canton

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Abstract: The goal of this research was to induce synchronization of estrus and ovulation in the Pramenka sheep breed using the photoperiod method, which is a method for manipulating the reproductive cycles of sheep by stimulating the sex drive in season and out of season by mating for fertilization and as many lambs in a short period of time as possible. Research was conducted on a private sheep farm in Una-Sana canton. In the method of artificial photoperiod regulation, a group of 36 sheep were used in the research, which were exposed to artificial light regulation and kept in a light-dark relationship (10 hours of light and 14 hours of darkness). Sheep were exposed to artificial photoperiod regulation for 60 days. After the 60th day, the ewes that showed estrus were released. After reception, the percentage of conception was determined, and after lambing, the number of lambs born per treated, received and lambed sheep. Regarding the estrous response of the Pramenka sheep, the results were as follows: early anestrus 52.7%, late anestrus 72.2% and breeding season 91.6%. When it comes to the distribution of the appearance of estrus after the end of the photoperiod method in a sample of a group of sheep, the largest number of treated ewes enter estrus in the first 6 days after treatment (87.8%), which should have been expected. The conception value after applying the photoperiod control method in three different stimulation seasons is good and amounts to 61.1% in early anestrus, 72.0% in late anestrus and 90.9% in the breeding season. The average number of lambs born per ewe ranged from 1.09 in the early anestrous season, 1.05 in the late anestrous season to 1.20 in the normal breeding season. Based on the obtained results, and the T-test, it was determined that there are no statistically significant differences between the stimulation seasons when it comes to the number of lambs born ($p>0.05$). The stimulation method for inducing fertile estrus did not significantly affect the number of lambs born per lambing ewe ($p>0.05$), and there were also no significant differences in the number of lambs born per treated, allowed, as well as per lambing ewe. The results indicate that the method of artificial photoperiod regulation as a measure of sustainable development of sheep breeding can be successfully applied to improve the reproductive characteristics of sheep and the method of increasing the number of lambs born per sheep per year in the researched area.

1. Introduction

Area of Una-Sana canton is a hilly area, with an average altitude of cca 350 m, with numerous pastures of high quality. Sheep farming is the traditional branch of agriculture, with optimal conditions for development [1]. The most of sheep breeds are seasonally polyestrous, meaning that their sexual activity takes place only during one annual season (mating season), while they are sexually inactive in other parts of year (seasonal anestrus). In the geodetic latitude of Una-Sana Canton, mating season starts by

the end of the summer, and finishes in the late autumn [1]. It has been long noted that the seasonal sexual activity is related to the changes in daily photoperiod, i.e. the seasonal anestrus matches the annual period of longer daylight. Considering the specific characteristics of natural reproductive activity of sheep which limit the annual lamb production, the methodology used for increase of the reproductive efficiency of sheep, is directed towards shorter or complete absence of seasonal anestrus, increase of the number of newborn lambs per fertile sheep, as well as the introduction of young fertile sheep into the breeding. In order to achieve this, there are several zootechnical methods, more or less efficient, with positive and negative characteristics. One of these methods is the method of artificial regulation of the photoperiod.

For the purpose, the paper explores the next reproductive characteristics of Pramenka sheep breed:
1. Estrus reaction after the application of the above mentioned method, during the three annual seasons,
2. Interval from the end of stimulation to the appearance of first estrus, during the three annual seasons,
3. The results of the concept,
4. Lambing results.

2. Material and Methods

The animals used for the research are of Bosnian autochthonous breed of Pramenka (from Kupres and from Travnik). The sample group included 36 sheep, and the same number was in control group. Research was conducted on a private sheep farm in Una-Sana canton.The sheep were held under the appropriate conditions and fed in a regular manner. During the summer, the sheep mostly stayed outside and were pasture-fed, while in the winter they were indoors, fed by the quality hay and by concentrated nutrients if necessary. All sample animals were sexually mature, having one to three lambings (mature sheep), fit and in good health. Research was conducted in three annual seasons: early anestrus season (January – February), late anestrus season (May – June) and natural mating season (half of the September to half of October).

All animals which manifested estrus after the treatment were naturally inseminated using the „hand mating“ method. During the experiment, the following data were collected and analyzed: date of the beginning of stimulation, date of the first occurrence of estrus after the stimulation, date of the fertile mating, number of sheep which were lambing after the mating in the first estrus after stimulation and number of newborn lamb per lambing sheep. Statistical analysis of the collected data was conducted by means of the statistical computer program PAST [2], using variance analysis (MANOVA) and Turkey's method for multiple comparisons.

3. Results and Discussion

The obtained results regarding the estrous reaction of Pramenka sheep, after applying the photoperiod method on a group of 36 sheep in a time interval of 60 days and artificial light regulation (10 hours of light and 14 hours of darkness), during three annual seasons (early anestrus, late anestrus and breeding season), are shown in the following tables:

Table 1. The value of the estrous response of Pramenka sheep after the application of the photoperiod method in three different annual seasons.

Stimulation season	Metod of the photoperiod		
	Treated sheep	Responding sheep	
	(n)	n	%
Early anestrus	36	19	52,7
Late anestrus	36	26	72,2
Mating season	36	33	91,6

Table 1. clearly shows that during the breeding season, ie. in the normal season, good results were achieved, a very high degree of estrous response was achieved (91.6%) of the treated sheep, while in the period of late and early anestrus, good results were also obtained (52.7% and 72.2%).
The results obtained, regarding the synchronization of estrus, with this method, do not deviate from the results obtained by many authors who dealt with this issue [1, 3, 4, 5, 6, 7, 8, 9].
The next investigated parameter was the distribution of the appearance of estrus after the end of the photoperiod method in the experimental group of sheep.

Table 2. Distribution of the appearance of estrus after the end of the photoperiod method in three different seasons in Pramenka sheep.

Stimulation season	Treatment - photoperiod method Days of occurrence of estrus					
	< 6		7 – 19		> 20	
	n	%	n	%	n	%
Early anestrus	15/19	78,9	4/19	21,1	-	-
Late anestrus	22/26	84,6	4/26	15,4	-	-
Mating season	33/33	100	-	-	-	-

Table 2 clearly shows that, regardless of the stimulation season, the largest number of treated sheep enter estrus within the first 6 days after the treatment period (87.8%), which was to be expected. Similar or similar results were obtained by other authors [1, 5, 6, 7, 8, 9, 10, 11, 12].

The next reproductive parameter that was investigated in this paper using the photoperiod method is the value of lambing (conception) of Pramenka sheep. The results of the mentioned parameter are presented in table 3.

Table 3. Conception value after natural insemination of Pramenka sheep subjected to the photoperiod method.

Stimulation season	The value of conception		
	Inseminated by sheep	Lamb of sheep	Conception
	n	n	%
Early anestrus	18	11	61,1
Late anestrus	25	18	72,0
Mating season	33	30	90,9

The results from table 3. clearly show that the value of conception after applying the photoperiod control method in three different stimulation seasons is good and amounts to 61.1% in early anestrus, 72.0% in late anestrus and 90.9% in the mating season. Similar results were obtained by other authors [1, 8, 9, 10, 13]).

The last investigated reproductive parameter using this method was the lambing value of Pramenka sheep. The value of the obtained lambs per treated, admitted and lambed sheep was determined. The results are shown in Table 4.

Table 4. Lambing results of Pramenka sheep subjected to the photoperiod method.

Stimulation season	Number of lambs born					
	Per treated sheep		Per admitted sheep		Per lambed sheep	
	n	X	n	X	n	X
Early anestrus	12/36	0,33	12/18	0,66	12/11	1,09
Late anestrus	19/36	0,52	19/25	0,76	19/18	1,05
Mating season	36/36	1,00	36/33	1,09	36/30	1,20

The table shows that the average number of lambs born per lambed ewe ranged from 1.09 in the early anestrus season, 1.05 in the late anestrus season and up to 1.20 in the normal breeding season. Similar results were obtained by other authors [14].

Based on the obtained results from table 19, it was determined based on the T-test that there are no statistically significant differences between the stimulation seasons when it comes to the number of lambs born ($p>0.05$) (table 5). The method of stimulation to induce fertile estrus did not significantly affect the number of lambs born ($p>0.05$) per lambed ewe, and there were also no significant differences in the number of lambs born per treated, allowed, as well as lambed ewe (table 6.)

Table 5. One-factorial ANOVA - stimulation season.

A source of variability	Sum of squared deviations	Degrees of freedom	Variance score	F- calculated	p - value
Between groups	0,272022	2	0,136011	1,808	0,2429
Within groups	0,4514	6	0,0752333		
Total:	0,723422	8			
omega^2:	0,1522				

Table 6. One-factorial ANOVA by treated, admitted, lambed sheep

A source of variability	Sum of squared deviations	Degrees of freedom	Variance score	F- calculated	p - value
Between groups	0,371622	2	0,185811	3,169	0,115
Within groups	0,3518	6	0,0586333		
Total:	0,723422	8			
omega^2:	0,3252				

4. Conclusion

Based on the review and analysis of the available literature, as well as our own results, in the field of establishing the sexual activity of sheep and the impact of the application of this method in increasing the reproductive activity of the Pramenka breed of sheep in the investigated locality, the following conclusions can be drawn:

a) Sheep are seasonally polyestrous animals, because they establish cyclical sexual activity only in one season (about 9-11 estrous cycles, mating season), i.e. in the second part of the year they are sexually inactive (seasonal anestrus). This phenomenon is a consequence of the fact that the sensitivity of the hypothalamic-pituitary axis to the negative feedback effect of estradiol depends on the length of the daily photoperiod. When the photoperiod is longer, the sensitivity of the hypothalamic-pituitary axis to estradiol is very strong, and one sequence in the estrous cycle is interrupted. That interrupted sequence is the non-secretion of the preovulatory LH wave, without which, consequently, there is no ovulation.
b) By applying the photoperiod method in a time interval of 60 days and artificial light regulation (10 hours of light and 14 hours of darkness), during three annual seasons (early anestrus, late anestrus and mating season), the following results were obtained in this work, regarding the examined parameters :
   - Estrous response after treatment with the mentioned method was very satisfactory, regardless of the treatment season. It ranged in Pramenko sheep, between 52.7% and 91.6%.
   - The largest number of treated sheep entered estrus within the first 6 days after treatment (78.9% in the early anestrus season, 84.6% in the late anestrus season and 100% in the mating season). The remaining ewes entered estrus at intervals of 7-19 days.
   - After this treatment, the value of conception after natural insemination of ewes that responded estrous was also satisfactory, regardless of the treatment season. It varied between 61.1% and 90.9% in Pramenko sheep.
   - After treatment with the photoperiod method, the number of lambs born per ewe was between 1.05 and 1.20.

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Comparison of the amount of harmful compounds in the use of conventional cigarettes and tobacco heating devices

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Abstract: Tobacco smoke adversely affects human health and the ecosystem, i.e. causes cardiovascular diseases, including stroke, cancer and chronic respiratory diseases, while harmful effects of cigarette butts on mosquitoes and sea snails have been discovered as well. Recently, a new alternative to the traditional tobacco product has been introduced to the market. These include smokeless tobacco, e-cigarettes, heated tobacco products, hybrid systems and tobacco vapor products. The tobacco heating system 2.2 (*THS 2.2, commercialized under the name IQOS*) uses an electronically controlled mechanism to precisely heat specially designed tobacco sticks at temperatures lower than those required for combustion. As a result, the aerosol produced by THS 2.2 contains significantly lower levels of harmful and potentially harmful constituents (HPHCs) than those found in cigarette smoke and without carbon-based solid particles. An extensive scientific assessment program has shown that these results in reduced cytotoxicity, in vitro genotoxicity and mutagenicity, lower *in vivo* harmful factors in animal models compared to referent cigarettes. This also results in significantly reduced exposure to HPHCs, excluding nicotine, in adult smokers switching from cigarettes to THS 2.2. When assessing THS 2.2, it is important not only to study the effect on its direct users, but also to determine whether there may be a possible impact on people in the surroundings.

1. Introduction

As a result of the effects of tobacco smoke on human health, about eight million people die each year worldwide. Out of that number, seven million deaths are related to direct cigarette use, while more than one million deaths are due to passive smoking. Over 80% of cigarette users live in countries with low and medium living standard.

Tobacco smoke, created as a result of tobacco burning, has become an undesirable social habit and is no longer acceptable in many social environments. Tobacco smoke adversely affects human health and the ecosystem, i.e. causes cardiovascular diseases, including stroke, cancer and chronic respiratory diseases, while harmful effects of cigarette butts on mosquitoes and sea snails have been discovered as well.

Tobacco smoking is addictive, damages all organic systems in the body and increases the risk of more than thirty diseases. Exposure to tobacco smoke also endangers the health of non-smokers, who as passive smokers are exposed to tobacco smoke (www.who.int;). Nicotine, as an integral part of tobacco, although addictive and not without risk, is not the primary cause of smoking-related diseases. According to NICE Public Health Guidance (NICE Public Health Guidance: Tobacco: Harm Reduction Approaches to Smoking) [1], toxins and carcinogens in tobacco smoke - not nicotine – are the primary causes of diseases and death.

Tobacco smoke produced by burning traditional cigarettes originates from the combustion of tobacco, additives, paper and complex organic material at very high combustion temperatures, which reach up to 1000° C. Combustion at such high temperatures produces more than 7,000 compounds in the gaseous and solid phases of smoke, of which 93 compounds are considered harmful or potentially harmful by the Food and Drug Administration (FDA). Tar is a solid phase of smoke and consists of several thousand particles, which are not gaseous and as such are deposited in human lungs. There are a large number of components in the composition of smoke that cause inflammation and irritation, have a carcinogenic effect, reduce oxygen flow or act by other mechanisms. Many components are already well known for their toxic mechanisms, such as: benzene (leukomogen), formaldehyde (irritant and carcinogen), benzo[a]pyrene (carcinogen), carbon monoxide (thickener) and others. Cigarette smoke also contains heavy metals and pesticides that contaminate tobacco used as raw material [2].

In recent years, there has been a global decline in cigarette smoking rates. However, this has not translated into a smaller number of smokers. In fact, even if the share of the population that smokes has dropped, the number of smokers has not, which is explained by the growth of total population [3]. In fact, there were 1.1 billion smokers in the world in 2007, and that number did not change until 2015 [3].

2. Results and discusion

Recognizing this, the strategy to reduce tobacco harm aims to make less harmful products available to smokers who would otherwise continue to smoke [4]. Recently, a new alternative to the traditional tobacco product has been introduced to the market. These include smokeless tobacco, e-cigarettes, heated tobacco products, hybrid systems and tobacco vapor products [4, 5, 6].

The tobacco heating system 2.2 (*THS 2.2, commercialized under the name IQOS*) uses an electronically controlled mechanism to precisely heat specially designed tobacco sticks at temperatures lower than those required for combustion [6]. As a result, the aerosol produced by THS 2.2 contains significantly lower levels of harmful and potentially harmful constituents (HPHCs) than those found in cigarette smoke and without carbon-based solid particles [7, 8, 9, 10]. Levels of acrolein and formaldehyde in the aerosol produced by THS 2.2 are lower than in cigarette smoke. The level of acrolein is lower for 89-95% and the level of formaldehyde is lower for 66-91% in aerosols which produce THS 2.2 than in cigarette smoke.

The levels of carbon monoxide and nitrogen oxides are for 97-99% lower in the aerosol produced by THS 2.2 compared to cigarette smoke. Reconstituted tobacco can produce high levels of carbon monoxide and nitrogen oxides during combustion [11]. Carbon monoxide is formed by an oxidative reaction at a higher combustion temperature range (>350°C) [7]. The levels of ammonia and acrylamide are for 63-68% lower in THS 2.2 aerosol compared to conventional cigarette smoke.

An extensive scientific assessment program has shown that this results in reduced cytotoxicity, in vitro genotoxicity and mutagenicity, lower *in vivo* harmful factors in animal models compared to referent cigarettes [6]. This also results in significantly reduced exposure to HPHCs, excluding nicotine, in adult smokers switching from cigarettes to THS 2.2 [6].

A study assessed the reduction in exposure to selected HPHCs in smokers switching to menthol cigarette heating systems (menthol Tobacco Heating System 2.2 - mTHS 2.2) compared with smokers who continue to smoke menthol cigarettes (mCCs) and people who abstained from smoking (smoking abstinence-SA). Also, the conducted study provides evidence of a lasting reduction in exposure after switching from mCC to mTHS comparable to the observed levels in those who abstain from smoking for the duration of the study.

mTHS provides an acceptable alternative to smokers in terms of taste, ritual, sensory experience, and may therefore be a suitable substitute for mCCs for adult smokers. Biomarkers of exposure to 16 HPHCs in blood and 24-hour urine were measured. The following biomarkers were determined: 4-aminobiphenyl; 2-cyanoethyl mercapturic acid; carboxyhemoglobin; creatinine; 2-hydroxyethylmercapturic acid; 3-hydroxy-1-methylpropylmercapturic acid; 3-hydroxypropylmercapturic acid; monohydroxybutenyl mercapturic acid; 1-aminonaphthalene; 2-aminonaphthalene; 4- (methylnitrosamino) -1- (3-pyridyl) -1-butanol; N-nitrosonornicotin; 3-hydroxy-benzo [a] pyrene; 1-hydroxypyrene; o-toluidine; S-phenylmercapturic acid [13].

When assessing THS 2.2, it is important not only to study the effect on its direct users, but also to determine whether there may be a possible impact on people in the surroundings. One way to assess this

is whether the use of the product indoors could have a measurable effect on air quality. In order to improve the understanding of indoor aerosols, a review of available information on environmental tobacco smoke or passive cigarette smoke (ETS) is required. ETS has been recognized as a contributor to indoor air pollutants, which negatively affects Indoor Air Quality (IQ) [13, 14]. ETS is an aged and diluted mixture of sidestream smoke emitted from the lit end of a smoked cigarette and from the smoker's exhaled smoke [15, 16]. Lateral smoke emanating from the sides of the tobacco product [17] accounts for 85% of indoor smoke [18] and is generated when burning a cigarette from the embers, at a temperature of 600°C and due to incomplete combustion of substances from tobacco, paper and additives N-nitrosamine concentrations 10 to 100 times higher are developed compared to smoke exhaled by smokers [19]. Lateral smoke contains higher concentrations of polycyclic aromatic hydrocarbons (PAH), nitrosamines and carbon monoxide. This is why side smoke causes a large number of cardiovascular diseases among non-smokers as well as lung cancer. Exposure to side smoke increases the risk of stroke and increases the tendency to form blood clots [2]. Cigarette smoke remains in the room air for the next eight hours [19].

It is important to mention the existence of the so-called third-hand smoke (THS). This is tobacco smoke that is retained in interior areas and is incorporated into wall materials, furniture, clothing and even toys after cessation of active smoking and can be re-emitted into the environment [20]. For example, released nicotine from certain materials can react with ozone and nitric acids present indoors and chemical reactions produce carcinogenic nitrosamine [21].

Exhalation of common smoke gives the ETS 3–11% carbon monoxide (CO), 15–43% particles and 1–9% nicotine [15]. In addition, cigarette smoke exhaled out of the mouth before inhalation (exhalation through mouth) can contribute to ETS [16].

In general, the same ingredients as in main and secondary smoke are present in ETS, although they are diluted and mixed with ingredients in ambient air [15, 16]. Smoke in the side stream is the main factor in ETS, it is slightly more alkaline than ordinary smoke because it contains larger amounts of ammonia and other bases.

Exhalation of common smoke is the second largest contributor to the ETS; it is important to emphasize that the amounts of nicotine and volatile compounds present in such smoke are significantly lower than those present in inhaled main smoke, since the smoker retains a large proportion of these substances after inhalation [15, 16]. The complex mixture of particles and components of the gas-vapor phase of ETS is rapidly diluted and dispersed after emission into the internal environment and undergoes changes in physicochemical properties due to shifts in the distribution of vapor particles, sorption and desorption of vapor phase components on internal surfaces and chemical reactions, however this has been insufficiently researched [22]. Thus, ETS has different physicochemical properties than that of conventional fumes. In particular, nicotine is almost entirely contained in the vapor phase of ETS, in contrast to its occurrence in the phase of main and side smoke particles [15].

Additionally, studies have shown that aerosols in the environment emitted by heated tobacco products have a much smaller impact on the indoor environment than ETS generated by cigarette smoking [23, 24, 5, 25, 26, 27, 28, 29, 30, 31]. This is to be expected, because on the one hand the aerosol generation of heated tobacco products does not involve tobacco combustion or pyrolysis at high temperature, leading to a significant reduction in the production of HPHCs. On the other hand, according to the design, electrically heated tobacco products do not have smoldering side smoke emitted at the top and generated by tobacco combustion, thus avoiding the main factors of indoor pollution caused by cigarettes.

Studies investigating the Electrically Heated Cigarette Smoking System (EHCSS), a precursor to the current THS 2.2, have shown a significant reduction in most airborne ingredients and ETS markers compared to the same resulting from cigarette smoking [24, 31]. Thus, aerosol environmental assessments of early generation EHCSS showed gas phase markers (CO, total volatile organic compounds [TVOC], 3-ethenylpyridine) similar to non-smoking levels, while ammonia concentrations were reduced by 40% and particle marker concentrations in cigarettes were higher than 90% [24]. A study conducted in simulated "Office" and "Hospitality" environments found that 24 of the 29 measured smoke ingredients had a mean reduction of more than 90%, and 5 smoke ingredients had a mean reduction of between 80% and 90% in experiments with EHCSS compared to cigarettes [31].

Throughout the assessment of Tobacco Heating Product - THP 1.0 (sold under the name Glo®) in the simulations "Office", "Catering" and "Residential", [23] reported that most of the 40 analyzed ingredients are below detectable or at initial levels other than nicotine, acetaldehyde, formaldehyde, and particulate matter (PM), which were usually higher but 90% lower than in cigarette smoke. Although one cigarette usually weighs less than 1 g, it can emit between 7 mg and 23 mg of particulate matter during smoking, depending on the smoking conditions and the type of cigarette brand, and the average particulate diameter is between 0.1 μm and 0.2 μm and they are classified as ultrafine particles that penetrate deep into the lungs and cause severe alveolar damage and irreversible lung injury [32].

THS is thought to release fewer chemical compounds because there is no tobacco combustion, leading to a reduction or elimination of compounds produced only at combustion temperatures. THS reaches temperatures of 300 - 350°C, as opposed to the combustion temperature zone of 700 - 900°C for conventional cigarette [6]. Indoor air quality during THS 2.2 use was tested in the model, surrounded by limited control of environmental parameters [27, 28, 29], in simulated spaces using control space [33] and in real environments (inside vehicle) [33]. Different air pollutants were investigated under different ventilation conditions and frequency of product use. All studies showed significantly lower emissions of toxic compounds in the indoor air compared to cigarettes. Also, in a study that assessed air quality during the use of THS 2.2 in indoor simulated spaces "office", "catering" and "residential" environments, the concentrations of 16 of the 18 tested ingredients did not increase the background concentrations found in non-smoking panelists present in a room under supervision and under equal conditions. The concentration of 18 indoor air components were measured (respirable suspended particles (RSP) <2.5 μm in diameter), ultraviolet particles (UVPM), fluorescent particles (FPM), solanesol, 3- ethenylpyridine, nicotine, 1,3-butadiene, acrylonitrile, benzene, isoprene, toluene, acetaldehyde, acrolein, crotonaldehyde, formaldehyde, carbon monoxide, nitrous oxide and combined nitrogen oxides). In the simulations that evaluated THS 2.2, the concentrations of most of the studied analytes did not exceed the background concentrations. Only the concentrations of acetaldehyde and nicotine increased above the baseline concentrations in all tested simulations with THS 2.2. In contrast, all simulations of smoking conventional cigarettes resulted in a significant increase in the concentrations of all measured constituents in the air determined when non-smokers were present in an environmentally controlled room under normal conditions [25].

3. Conclusion

The analysis showed that in the simulated environmental conditions only three compounds (nicotine, acetaldehyde diglycerin) are released when using THS 2.2 indoors. The quantified concentrations of these three compounds in the air during the use of THS 2.2 indoors in environmental studies were below the hazard levels defined by the competent authorities. Thus, normal hygiene measures, such as regular ventilation of living spaces, would lead to effective control of these low to negligible levels of pollution. Furthermore, the assessment of the concentrations of PM, volatile organic compounds (VOCs) and semi volatile ETS markers during simulations after the use of THS 2.2 showed that the aerosol THS 2.2 is very different from tobacco smoke, i.e. ETS emitted during cigarette smoking.

Based on these data, it is reasonable to conclude that the use of THS 2.2 in environments where standards are prescribed for internal exposure and where the conditions for adequate ventilation are complied with does not adversely affect the overall indoor air quality.

The transition from mCC to mTHS significantly reduced HPHC exposure to levels approaching those observed in subjects who abstained from smoking during the study. Also, heating tobacco instead of burning it creates a far less complex aerosol compared to cigarette smoke, resulting in a significant reduction or elimination of HPHC exposure.

In addition, previous research has shown that smokeless alternatives, the so-called electric cigarette. E cigarettes (electrical nicotine delivery system-ENDS) and THS devices emit significantly smaller amounts of airborne particles of all dimensions and harmful substances compared to conventional cigarettes. In many countries, the use of ENDS devices indoors is still not banned, although numerous studies indicate the negative effects of regular passive exposure to ENDS vapors.

Based on previous research, it can be concluded that cigarettes are harmful to human health, and the best option is certainly to never start smoking. If a person is already a smoker, it is best to stop this habit

as soon as possible. Those who will not easily give up these habits, despite numerous attempts, should be informed that there are less harmful alternatives to smoking on the market.

It is also necessary to emphasize that ENDS and THS devices are more recent and that further research isneeded to better explain their impact on human health and the ecosystem.

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Chemical and microbiological analysis of different samples of honey from Bosnia and Herzegovina

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Abstract. Honey is completely a natural product that can be used directly from the hive in its natural form, in that condition, in which his bees produced. The miraculous properties of honey as food and medicine, special and remarkable sweet taste, unattainable, easy absorption, a quick refreshing effect on human organism, have made the honey the most attractive, most valuable and most valuable food and product of wide spectrum and varied use since the very far past to this day. In chemical terms, it represents a complex mixture of various active substances that are digested very well and quickly in the human body and are almost completely exploited. Since honey is a good bioindicator of environmental pollution, the proportion of metals (especially heavy) is used as an indicator of environmental pollution. The aim of this study was to determine the microbiological quality of honey, physical - chemical characteristics of different types of honey from the territory of Bosnia and Herzegovina, and on the basis of the investigated heavy metals in honey to determine the degree of environmental pollution in cities. The study was done on five samples of honey from 2018.

1. Introduction

Honey is an extremely high-quality food product that honey bees (*Apis mellifera*) make from certain nutritious juices of plant origin (nectar and honeydew, juice of plant fruits) found on living parts of plants, processed with the help of enzymes from their digestive tract and mechanically removing water. Carbohydrates are the main ingredient of honey and their percentage is 73-83%, which makes honey a supersaturated sugar solution. The most abundant are fructose, with a share of 33.3 - 40% and glucose with a share of 25.2 - 35.3%. Qualitative and quantitative determination of carbohydrates in honey is the subject of many studies, whether it is routine quality assessments (according to the Ordinance), determining honey adulteration or determining the botanical and/or geographical origin of honey. Determining sucrose is important in order to determine possible adulteration of honey, feeding bees with sugar (sucrose) or direct addition of sugar to honey [1]. Indirect adulteration involves feeding bees to improve yields and is extremely difficult to detect (Zábrodská and Vorlová, 2014; Milojković Opsenica et al., 2015). Many researchers believe that the main amount of protein in honey comes from the glands of bees during the processing of nectar into honey and during the processing of honeydew. Some amino acids participate in the creation of a certain aroma of honey [2]. Enzymes together with proteins in honey give it properties that cannot be artificially produced or replaced [3]. Diastase, which is also called

amylase, is of great importance for honey quality control. Quality honey must have a diastasis indicator of 8 units according to Goethe.

Diastasis in honey is sensitive to its heating. It deteriorates if the heating temperature is too high or if the honey is stored for a long time in poor temperature conditions (Olaitan et al., 2007). Types of honey that are darker in color are more acidic, so honey from a honeypot has a lower pH than honey that comes from nectar. If honey has more sodium, potassium and calcium salts, it will also have a higher pH value. Although the presence of acids in honey is mostly a positive feature because it contributes to the fullness of its taste, it is also possible to find undesirable acids in honey that are formed after fermentation, that is, after spoilage of honey [5].

Minerals are present in honey in small quantities, and the most abundant is potassium. Dark honeys have a higher proportion of minerals. A small proportion of ash in acacia and sunflower honey is characteristic, and a large proportion in chestnut and meadow honey and honeydew honey. The minerals, K, Na, Ca, P, S, Cl, Mg, Fe and Al are dominating, while Cu, Nn, Cr, Zn, Ps, Tr, Ar are slightly present. How many of them there will be in honey mostly depends on its botanical origin, but also on the climatic conditions and composition of the soil where the honey plant grew. The characteristic soil system of a certain region is also reflected in the mineral composition of the honey plant, i.e. the mineral composition of its nectar and pollen. Therefore, the proportion and system of mineral substances in honey is often used to determine the botanical and geographical origin of honey [6]. The antimicrobial and antiviral activity of honey has been proven by scientific research, where the low activity of water inhibits the growth of bacteria, which contributes to the antibacterial effect [7]. The antimicrobial activity of honey is related to hydrogen peroxide, obtained in a reaction catalyzed by glucose oxidase, and phenolic components, although the inhibition of microorganisms with the help of the mentioned components varies depending on the botanical origin of the nectar [8].

2. Materials and methods

2.1. Determination of water in honey by the drying method, standard procedure

Principle: the method of determining water by drying is based on drying the sample to a constant mass in various types of dryers. From the difference in the weight of the container with the sample before and after drying, the water content is calculated:

Water content = a x 100/Ok

where is:

a – the difference in the weight of the container with the sample before and after drying (g)

Ok – measured amount of sample (g)

2.2. Determination of hydroxymethylfurfural – photometric method according to Winkler

This method is based on the reaction of hydroxymethylfurfural with barbituric acid and p-toluidine, where a pink color is formed, which must be measured at a wavelength of 550 nm. The sample is prepared in the manner established for the sample preparation method for analysis, without heating. 10 g of the sample is weighed and dissolved in 20 ml of oxygen-free distilled water without heating. It is then transferred to a measuring flask with a volume of 50 ml, which is topped up with water up to the mark (honey solution). Immediately after preparation, determination continues.

From the prepared sample, measure 2 ml with a pipette, transfer it to each of the two test tubes, and then add 5 ml of p-toluidine. Pipette 1 ml of water into one test tube, and 1 ml of barbituric acid solution into the other, then mix the contents well. The test tube containing the water will be used for the blank test. The reagent should be added without interruption, and everything must be completed in 1-2 minutes. When the color intensity reaches the maximum (3-4 minutes), the absorbance at 550 nm is read in a 10 mm cuvette.

The amount of hydroxymethylfurfurol is expressed in mg/100 g of honey, and is roughly calculated according to the formula:

mg HMF/100 g honey = apsorbance/layer thickness x 19,2

2.3. Determination of heavy metals in honey

The first step for the determination of heavy metals is the digestion (destruction) of the sample, which is performed according to the instructions of the microwave oven equipment manufacturer (Milestone):

- weigh 0.5g of the sample in the digestion cuvette;
- add 7ml HNO3 and 1ml H2O2;
- close the cuvettes with a torque wrench;
- place the cuvettes of the microwave oven bed for digestion;
- set the digestion program (10 min. at 200 ◘ C, power 1000w);
- after digestion and cooling of the cuvette (max. 50 ◘ C), transfer the content of the cuvette into a 50ml volumetric flask and top up with distilled water up to the mark.

The samples prepared in this way are analyzed on an atomic absorption spectrophotometer with previously prepared standard solutions that serve to create a calibration curve.

3. Results and discussion

Based on the previously described analyses, the following results were obtained for a total of 5 tested samples of honey from the area of cities in Bosnia and Herzegovina (Sarajevo, Tuzla, Bihać, Bužim, Cazin) shown in Table 1. A 250g sample of honey was used for the laboratory analysis upon examination. The tests were carried out in the honey quality control laboratory of the JU " Veterinary Institute USK" in the Bihać.

Table 1. Microbiological correctness of honey.

Analysis/accreditation parameter	**MJ**	**MDK**	**RESULTS**				
			1.	2.	3.	4.	5.
			LM Sarajevo	LM Bihać	KM Cazin	KM Bužim	KM Tuzla
Total of aerobic colonies BAS EN ISO4833-1 : 2014	*cfu/g	m=1000	$3{,}2x10^4$	‹10	$5x10^4$	‹10	$7{,}2x10^4$
ENTEROBACTERIACEAE BAS EN ISO 21528-2 : 2018	*cfu/g	m=10	‹10	‹10	‹10	‹10	‹10
Sulphite-Reducing Clostridia BAS ISO 15213 : 2008	*cfu/g	m=10	‹10	‹10	‹10	‹10	‹10
Yeasts and Molds BAS ISO 21527-2 : 2009	*cfu/g	m=10	‹10	‹10	‹10	‹10	$3x10^3$

LM= meadow honey; KM= chestnut honey

All tested samples for the tested parameters of enterobacteriaceae and sulphite-reducing clostridia correspond to the provisions of MDK. Samples 1 and 2 have deviations in relation to the MDK for the required test parameter, the total sum of aerobic colonies, while sample 5, in addition to this, also has deviations in yeast and mold tests.

Table 2. Physical and chemical correctness of honey.

Analysis/accreditation parameter	**MDK/MJ**	**RESULTS**				
		1.	2.	3.	4.	5.
		LM Sarajevo	LM Bihać	KM Cazin	KM Bužim	KM Tuzla
Water content "Official Gazette of BiH No. 37/09", section E.b*	20%	14,5	14,1	16,0	17,8	13,9
Hydroxylmetylfurfural ("Official Gazette of BiH No. 37/09", section J.a)*	40mg/kg	8,2	3,9	1,8	4,6	294,7

Samples number 1, 2, 4, and 5 for the tested parameters: water content and HMF correspond to the provisions of the Ordinance on honey and other bee products ("Official Gazette of BiH No. 37/09") ANNEX. Sample number 3 on the tested parameter: water content corresponds to the provisions of the Ordinance on honey and other bee products ("Official Gazette of BiH No. 37/09") ANNEX, on the tested parameter: HMF does not correspond to the provisions of the Ordinance on honey and other bee products. Methods marked with * are accredited according to the requirements of Standards BAS EN ISO/IEC 17025:2006 by the BiH Accreditation Institute (No. Li – 24 – 01).

MDK taken from guidelines on microbiological criteria for food (Food Safety Agency of BiH, Mostar 2013). The results of the analysis by atomic absorption spectrophotometry (AAS) were expressed in mg/kg, and the standard in the analysis was 0.5 mg/kg, 1 mg/kg and 2 mg/kg. Table 3 shows the concentrations of copper in each of the samples. The content of copper in honey samples was determined by the flame technique on AAS (Shimadzu 6800) in cooperation with JU "Agricultural Institute USK" in the Bihać.

Table 3. Heavy metals in honey.

Analysis/accreditation parameter	**MDK/MJ**	**RESULTS**				
		1.	2.	3.	4.	5.
		LM Sarajevo	LM Bihać	KM Cazin	KM Bužim	KM Tuzla
Copper BAS EN 14084:2005	2 mg/kg	1.0723	0.4093	0.5613	0.6404	1.8904

All tested samples for the tested parameter determination of Cu content correspond to the provisions of the Ordinance on honey and other bee products ("Official Gazette of BiH No. 37/09") ANNEX.

4. Conclusion

The purpose of honey analysis is to determine the quality, plant origin and possible falsification. Honey is a bee product that is relatively easy to falsify, and the falsification can be so skillful that even the most experienced experts find it difficult to detect. Rough falsifications of natural honey, such as the addition of mineral pigments, sugar syrup, ordinary sugar, invert sugar, industrial glucose, etc., are rare and easily detected by simple methods. It is relatively more difficult to identify sugar honey. The quality of honey can also deteriorate due to improper technological processes of obtaining, processing and storing it, such as heating at a high temperature, storing in unfavorable conditions, pollution, etc. The composition of microflora depends on the diversity of the chemical composition of honey. Bee honey is a medium whose physical and chemical properties suppress the development of microorganisms. A large amount of sugar causes a high osmotic pressure, which does not allow the reproduction of microorganisms. Microorganisms do not reproduce at sugar concentrations above 20%. Only osmophilic yeasts can reproduce in honey under certain conditions (amount of water above 20%) and cause fermentation

processes. It is an interesting fact that honey can also serve as a bioindicator of environmental conditions. Metal concentrations in the environment can be increased by various influences, and a special danger is the characteristic of heavy metals that they accumulate in living organisms and disrupt the natural balance in food chains.

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Experimental investigation: possibility of phytoremediation with the aromatic plant lavender on soil contaminated by heavy metals lead and cadmium

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Abstract. This paper presents an examination of the effectiveness of plant culture lavender (lat. *Lavandula spica* L.) in phytoremediation of soil contaminated with heavy metals lead and cadmium. The experiment was performed in laboratory controlled conditions on 10 lavender seedlings that were planted in 5 kg of soil and watered with a solution of heavy metals for a period of three months. The flame method of atomic absorption spectrophotometry was used to determine the concentration of heavy metals. The results showed that the average concentration for lead was 1477,3 mg/kg, and for cadmium 234,2 mg/kg of dry matter. The average value of the phytoaccumulation factor for lead was 4,5 and for cadmium 4,1. The highest value of the phytoaccumulation factor for lead and cadmium were detected in plant material which had been watered with the smallest volume of heavy metal solution having the lowest concentration of heavy metals in the soil. Based on the results, lavender plant culture can be considered hyperaccumulator of lead and cadmium. Also, heavy metals do not affect the growth and development of lavender, which can be used for the production of essential oil, and is an economical way of eliminating heavy metals from the soil.

1. Introduction

Soil represents an important environmental component that attracts increasing attention due to its role in the further distribution of pollution in the environment, as it represents the basic foundation of agricultural resources, food security, global economy and environmental protection [1]. The soil is also the ultimate recipient of all pollution, regardless of whether it is released into the air, water or deposited on the ground. One of the most common risks for human health and the environment is soil contaminated with heavy metals. Soil pollution is significantly different from air or water pollution in that heavy metals remain in soil longer than in other environmental components. Also, heavy metals are natural components of the Earth's crust, they are difficult to degrade by microorganisms, accumulate in living organisms, and in polluted areas heavy metals can enter the body through air, food and water, causing long-term health consequences [2].

Metals and metalloids belonging to the group of heavy metals are those whose density is greater than or equal to 5 g/cm^3, and include micronutrients such as cobalt, copper, iron, chromium, molybdenum, manganese and zinc, which belong to the group of essential elements, and heavy metals include biologically non-essential elements such as cadmium, chromium, lead, mercury, nickel, uranium,

vanadium and wolfram [3]. Increased concentrations of lead and cadmium are typical for urban pollution, considering that the largest amounts of cadmium in the soil come from the atmosphere through the emission of exhaust gases. Areas in the zone of influence of highways and other main roads are polluted primarily by lead and cadmium, but also by other heavy metals [4, 5], and in the last few decades around the world around 783,000 tons of lead and 22,000 tons of cadmium are released annually [6].

The problem of the heavy metals accumulation in the soil has so far been solved by expensive, abrasive, chemical and physical methods, which, due to the lack of a universal chemical that would be used for all metals, were not sufficiently efficient, easily applicable and profitable [7]. In order to remediate long-term pollution and reduce the negative impact of new pollution, in recent years more and more attention has been paid to the application of biological, less obstructive technologies and numerous remediation procedures are carried out in the domain of a new interdisciplinary scientific discipline called phytoremediation [8]. Phytoremediation uses plants that have the ability to accumulate and detoxify heavy metals and organic pollutants with the aim of restoring and cleaning polluted habitats by translocating them to their above ground parts [9].

The aim of this work was to examine the possibility and degree of lead (Pb) and cadmium (Cd) uptake from contaminated soil by lavender (lat. *Lavandula spica* L.) as a phytoremediation agent in laboratory controlled conditions. Lavender is a plant crop that is widely distributed in the continental area and does not require special conditions when growing, and if it is suitable as a phytoremediation agent, it can be used in the rehabilitation of soil where an increased concentration of lead and cadmium is expected or proven.

2. Material and methods

This work represents research on artificially polluted soil that was treated with a solution of heavy metals in laboratory conditions and in which lavender was grown, and was carried out in three phases:

a) In the first phase, lavander was planted;
b) In the second phase, lavander was watered with a solution of heavy metals and in this way the soil in which the plants were grown was artificially polluted;
c) In the third phase, lavander was removed from the soil and dried, the plant material was homogenized and the concentration of heavy metals in the plant material was determined.

The plants were watered every five days for a period of three months in such a way that the first pot was watered only with water and were determined as control samples for monitoring the natural concentration of heavy metals in the plant material. In the other pots, from the second to the tenth, the soil was treated with a solution containing the heavy metals Pb and Cd. The soil was watered 18 times.

Figure 1. Analyzed lavender plant cultures.

The soil in the pots was watered with a 0,05 M solution of lead(II) nitrate ($Pb(NO_3)_2$) and a 0,02 M solution of cadmium sulfate octahydrate ($3CdSO_4 \cdot 8H_20$). The solutions were prepared by dissolving in distilled water 16,56 g of Pb(NO3)2, molar mass 331,2 g/mol and 15,39 g $3CdSO_4 \cdot 8H_20$, molar mass 769,546 g/mol, and the volume of the solution was increased due to testing the optimal volume and concentrations that can be absorbed by plant crops and that will not interfere with their growth and development.

The material of this paper represented 10 samples of lavender plant material that were grown on soil artificially polluted with heavy metals Pb and Cd. Concentrations of heavy metals in plant material were determined by atomic absorption spectrophotometry.

Seedlings of lavender plant culture from domestic cultivation were planted in plastic pots, in such a way that 10 lavender seedlings of about 10 cm were planted in 5 kg of soil in 10 pots (Figure 1.) in April 2021. Pots with lavander were placed in an area illuminated by natural light and after 7 days of adaptation, the soil was artificially polluted. After the watering period, the plant cultures were removed from the soil, the roots were washed with distilled water and the plant material was air-dried in laboratory conditions.

Samples were prepared using the dry burning technique. At first ten samples of dried lavender were homogenized (root, stem and leaves) and ground into a fine powder. Then the samples were weighed (approx 1 gram) and burned in a preheated porcelain pot on a burner until all the mass was charred and smoke stopped forming. Then the samples were annealed in an annealing furnace (Selecta) at 550°C until the organic substances were completely destroyed and the ash became completely white. After annealing, the samples were cooled in a desiccator. The samples were annealed again for 10 to 30 minutes, cooled in a desiccator and weighed to a constant mass. After annealing, the contents of the crucible were qualitatively transferred into a 100 cm^3 volumetric flask and topped up to the mark with 10% nitric acid (HNO_3) [10]. In the samples prepared in this way, the absorbances were read on an atomic absorption spectrophotometer using the flame technique.

Concentrations of heavy metals Pb and Cd in plant material were determined by the method of flame atomic absorption spectrophotometry "Analytical Methods" FP-3 Analysis (2000) [11] on an atomic absorption spectrophotometer with Zeman correction "Perkin Elmer" Aanalyst-800.

An atomic absorption spectrophotometer (AAS) is a device used in determining the concentration of metal ions in samples. Most routine analyzes require a flame temperature of around 2400°C, which can be achieved with air-acetylene or oxygen-hydrogen mixtures on recommended conditions (Table 1.). The sample for analysis in the liquid state is introduced into the flame using a sprayer, which achieves dispersion of the liquid into fine droplets [12, 13].

Table 1. Recommended conditions for AAS analysis.

Element	**Pb**	**Cd**
Flame	Air-acetylene	Air-acetylene
Wavelenght	283,3 nm	228,8 nm
Opening	0.7 nm	0.7 nm
Way	AA-BG	AA-BG
Burner	10 cm	10 cm
Atomizer	Highly sensitive	Highly sensitive
Signal measurement	Peak area	Peak area
Calibration method	Linear through zero	Linear through zero
Stock Standard Solution (mg/l)	Lead 1000 mg/l; St . 20 mg/l	Cadmium 1000mg/l ; St. 2 mg/l

The instrument measures each standard or sample three times, performs measurement statistics, constructs a calibration diagram and calculates the concentration of the unknown sample. The conditions under which the analysis of heavy metals was performed are shown in Table 1, and the technique used was AA Flame, Spectrometer Model: AA800, S/N 7121402.

3. Phytoaccumulation factor (FAF)

In order to determine the relationship between the concentration of heavy metals in plant material and the soil, i.e. the ability to phytoaccumulate heavy metals, the phytoaccumulation factor (FAF), which is called and bioaccumulation factor (BF), calculated according to the formula (1):

$$FAF = \frac{heavy\ metals\ concentration\ in\ the\ dry\ matter\ (\frac{mg}{kg})}{heavy\ metals\ concentration\ in\ soil\ (\frac{mg}{kg})} \quad (1)$$

The phytoaccumulation factor wasn't calculated for the control samples, and the concentrations of heavy metals in the soil were calculated based on the mass of the solution of lead(II) nitrate ($Pb(NO_3)_2$) and the solution of cadmium sulfate octahydrate ($3CdSO_4 \cdot 8H_20$), which was added to 5 kg of soil in which lavender was grown.

4. Results

This chapter presents the results of the research and certain concentrations of the heavy metals Pb and Cd in the plant material, which are expressed in the unit of measurement mg/kg of dry matter (Table 2.). The ratio of heavy metal concentrations in the plant material samples were unevenly distributed, and the concentration of heavy metals in the plant material did not depend on the volume of the heavy metal solution with which the plants were watered. Heavy metal concentrations were determined with an average standard deviation of 0,22% for Pb and 0,10% for Cd in lavender plant material.

Table 2. Concentrations of heavy metals Pb and Cd in lavender plant culture samples.

Sample mark	LEAD (mg/kg)	Standard deviation (%)	CADMIUM (mg/kg)	Standard deviation (%)
L-1	610,5	0,029	9,7	0,003
L-2	1299,8	0,146	312,5	0,480
L-3	1503,2	0,142	288,4	0,021
L-4	2011,8	0,409	439,4	0,167
L-5	933,9	0,098	246,6	0,015
L-6	649,4	0,054	34,8	0,002
L-7	729,4	0,038	91,4	0,008
L-8	2109,6	0,309	534,2	0,217
L-9	1029,8	0,099	61,1	0,011
L-10	3895,8	0,828	323,5	0,045
Average	1477,3	0,220	234,2	0,100

The concentration of the heavy metal Pb in the control sample of the dry matter of lavender plant culture, i.e. sample L-1, which is not artificially contaminated with heavy metals, is 610,5 mg/kg. The concentration in the other samples (Figure 2.) ranges from 649,4 to 3895,8 mg/kg of dry matter.

The highest concentration of Pb was read in sample L-10 and is 3895,8 mg/kg, then in sample L-8 where it is 2109,6 mg/kg and in sample L-4 where it is 2011,8 mg/kg. Mean Pb concentrations were read in sample L-3 where it is 1503,2 mg/kg, then in sample L-2 where it is 1299,8 mg/kg and in sample L-9 where it is 1029,8 mg/kg.

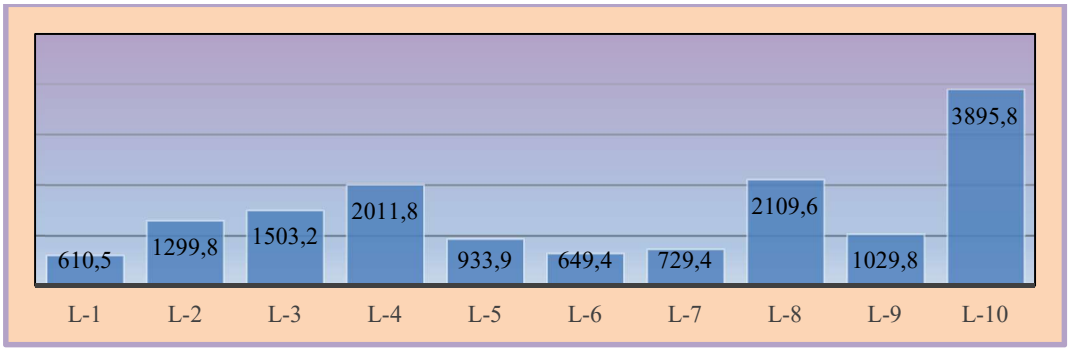

Figure 2. Lead (Pb) concentrations in lavender samples.

The lowest concentrations of Pb, in addition to the control sample, were read in sample L-5 where it is 933,9 mg/kg, then in sample L-7 where it is 729,4 mg/kg and the lowest concentration in sample L-6 where it is 649,4 mg/kg. The maximum Pb concentration absorbed by the lavender plant cultures from the artificially polluted soil is 3895,8 mg/kg ant it's 6,38 times higher than the Pb concentration in the control sample, which is 610,5 mg/kg, and the lowest measured Pb concentration which amounts to 649,4 mg/kg is approximately equal to the concentration of Pb in the control sample. The highest concentration of Pb was measured in the sample that was watered with the largest amount of heavy metal solution, that is, with a 0,02 M solution of cadmium sulfate octahydrate ($3CdSO_4 \cdot 8H_20$). The average concentration of lead (Pb) in samples of lavender grown in polluted soil (samples L-2 to L-10) is 1573,6 mg/kg of dry matter, which is 2,58 times higher than the concentration of Pb in the control sample (sample L-1), and the concentration of Pb in lavender is not directly related to the concentration of Pb in the soil where the lavender was grown. The average value of phytoaccumulation factor Pb (Table 3.) is 4,5 for lavender plant material.

Table 3. Phytoaccumulation factor of Pb for lavender plant material.

Sample	conc. Pb in lavander (mg/kg)	conc. Pb in soil (mg/kg)	FAF (Pb)
L-1	-	-	-
L-2	1299,8	103,6	12,5
L-3	1503,2	207,2	7,3
L-4	2011,8	310,8	6,5
L-5	933,9	414,4	2,3
L-6	649,4	497,3	1,3
L-7	729,4	559,5	1,3
L-8	2109,6	621,6	3,4
L-9	1029,8	725,2	1,4
L-10	3895,8	828,8	4,7
Average	1573,6	474,3	4,5

The concentration of the heavy metal Cd in the control sample of lavender plant culture, i.e. sample L-1, which is not artificially contaminated with heavy metals is 9,7 mg/kg. The ratio of Cd concentrations in other samples (Figure 3.) ranges from 34,8 to 534,2 mg/kg of dry matter.

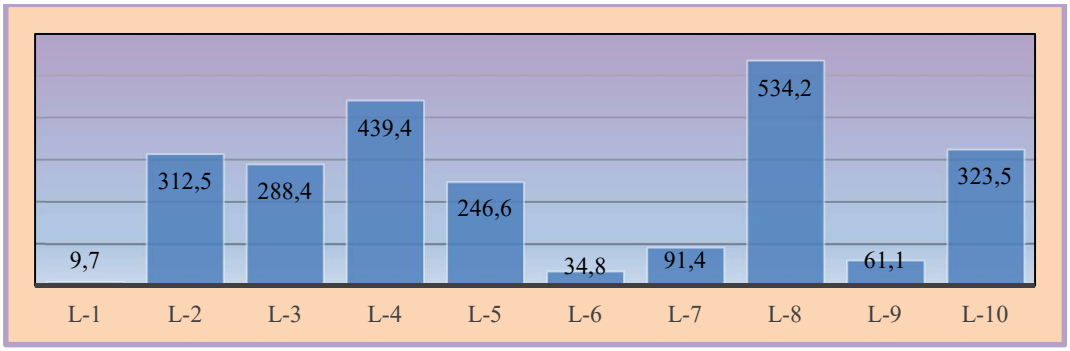

Figure 3. Cadmium (Cd) concentrations in lavender samples.

The highest concentration of Cd was read in sample L-8 and is 534,2 mg/kg, then in cause L-4 where it is 439,4 mg/kg. Mean Cd concentrations were read in sample L-10 where it is 323,5 mg/kg, then in sample L-2 where it is 312,5 mg/kg, then in sample L-3 where it is 288,4 mg/kg and in sample L-5 where it is 246,6 mg/kg of dry matter. The lowest concentrations of Cd, in addition to the control sample, were read in sample L-7 where it is 91,4 mg/kg, then in sample L-9 where it is 61,1 mg/kg and the lowest concentration of Cd in sample L-6 where it is 34,8 mg/kg of dry matter. The maximum concentration of the heavy metal Cd absorbed by lavender plants from artificially polluted soil, which is 534,2 mg/kg, is 55,07 times higher than the concentration of Cd in the control sample, which is 9,7 mg/kg, and the lowest the measured Cd concentration is 34,8 mg/kg and is approximately equal to the Cd concentration in the control sample.

The average concentration of Cd in lavender samples in polluted soil (samples 2 to 10) is 259,1 mg/kg of dry matter, which is 26,71 times higher than the concentration of Cd in the control sample (sample L-1), and the concentration Cd in lavender is not directly related to the concentration of Cd in the soil where the lavender was grown. The average value of phytoaccumulation factor Cd (Table 4.) is 4,1 for lavender plant material.

Table 4. Phytoaccumulation factor Cd for lavender plant material.

Sample	conc. Cd in lavander (mg/kg)	conc. Cd in soil (mg/kg)	FAF (Cd)
L-1	-	-	-
L-2	312,5	22,5	13,9
L-3	288,4	45,0	6,4
L-4	439,4	67,4	6,5
L-5	246,6	89,9	2,7
L-6	34,8	107,9	0,3
L-7	91,4	121,4	0,8
L-8	534,2	134,9	4,0
L-9	61,1	157,4	0,4
L-10	323,5	179,8	1,8
Average	259,1	102,9	4,1

Lavender plant culture absorbed larger amounts of lead than cadmium (Figure 4.). The average concentration of heavy metals in lavender samples is 1711,48 mg/kg of dry matter, distributed as 1477,32 mg/kg on lead and 234,16 mg/kg is cadmium. At the end of the watering period, the lavender plant material showed no signs of disease in the plant material.

The ratio of uptake of the observed metals (Figure 4.) in the lavender plant material is continuously several times (4-18) higher in favor of lead, in all observed samples. This relationship in lavender plants

is based on the fact that the concentration of lead in the soil is 4,6 times higher than the concentration of cadmium in all samples.

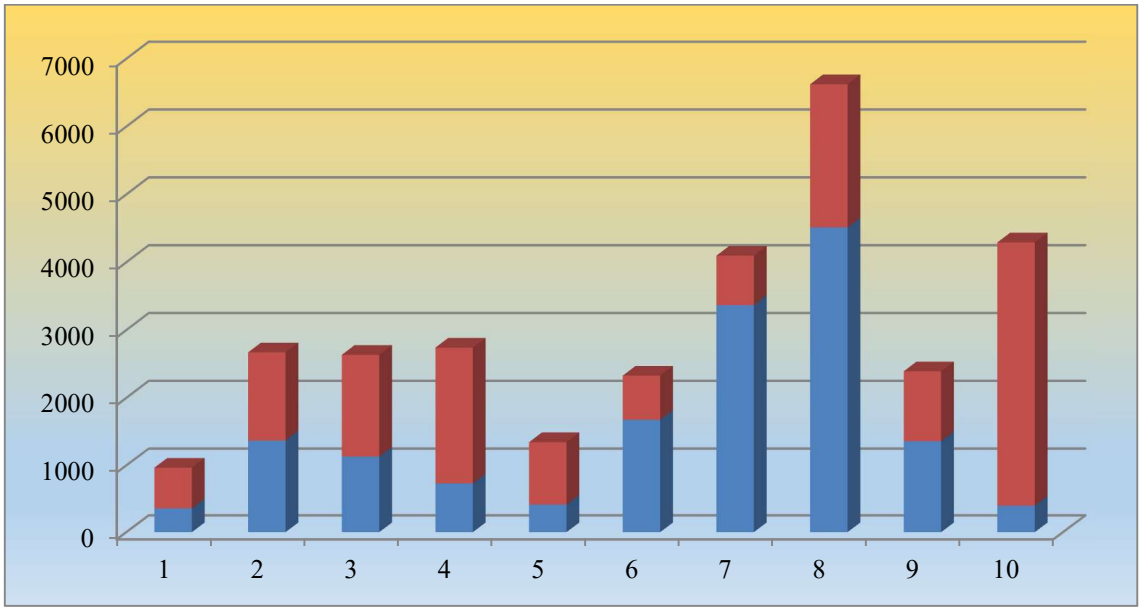

Figure 4. Graphic representation of lead and cadmium concentrations in lavender plant material.

5. Discussion

If the value of the phytoaccumulation factor of a certain heavy metal is greater than 1, this indicates that the investigated plant culture can be considered a hyperaccumulator of that heavy metal [14]. Thus, the lavender plant can be considered a hyperaccumulator for the heavy metals Pb and Cd.

In the literature, the published values for the phytoaccumulation factor of Pb in addition to lavender were also determined for the aromatic plants mint (*Mentha pipereta* L.), centella or tiger grass (lat. *Centella asiatica* L.) and orthosiphon (lat. *Orthosiphon stamineus* Benth) in the research of Abd Manan and associates in 2015, who found that the phytoaccumulation factor of Pb is 0,05 for centella or tiger grass and 0,54 for orthosiphon [15]. The lavender plant culture used in this work has a higher lead phytoaccumulation factor (4,5) compared to the aromatic plants centella or tiger grass and orthosiphon.

Research on the ability to accumulate heavy metals Pb and Cd was also conducted on different wild plants. Stančić et al., in 2015 [14] showed the values of Pb and Cd in the plant material of different types of plants in the area of the city of Varaždin in Croatia. The values of Pb measured in plants range from 0,08 to 0,97 mg/kg, and the greatest capacity for phytoaccumulation of Pb was shown by one-year-old sedge (lat. *Erigeron annuus* L.) with 0,97 mg/kg, followed by plantain or buckthorn (lat. *Plantago lanceolata* L.) with 0,63 mg/kg and white clover (lat. *Trifolium repens* L.) with 0,42 mg/kg. All values are much lower compared to the concentration of Pb in lavender presented in this paper. The values of Cd measured in plants range from 0,01 to 0,62 mg/kg, and the highest ability of phytoaccumulation is shown by dandelion (lat. *Taraxacum officinale* F. H. Wigg) with 0,41 mg/kg, then chicory (lat. *Cichorium intybus* L.) with 0,32 mg/kg and plantain or plantain (lat. *Plantago lanceolata* L.) with 0,25 mg/kg, which are also lower values compared to the values (4,5 for Pb and 4,1 for Cd) presented in this work.

Another study of the phytoaccumulation capabilities of the dandelion plant culture (lat. *Taraxacum officinale* F.H. Wigg) was conducted by Šaćiragić-Borić in 2012 at six locations (Sarajevo, Fojnica, Cazin, Goražde, Počitelj and Živinice) in Bosnia and Herzegovina [16]. The values of the heavy metal Cd in the dandelion leaf ranged from 0,29 to 0,75 mg/kg, and for Pb in the range from 0,45 to 14,22 mg/kg. The values of Pb in dandelion roots ranged from 1,26 to 29,45 mg/kg, cadmium from 0,31 to 0,88 mg/kg. The paper indicates that dandelions in Bosnia and Herzegovina accumulated more Cd and

Pb compared to the accumulated concentrations in Croatia, which are also much lower compared to the concentrations of Pb and Cd accumulated in lavender in this paper.

Research by Salama et al., in 2015, who investigated the phytoremediation ability of the plant culture of ryegrass (lat. *Lolium multiflorum* Lam.) showed that the average concentration of Pb was 186,15 mg/kg and Cd 253,05 mg/kg in the plant material of ryegrass grown on contaminated soil. The average phytoremediation factor for Pb is 0,4961 and for Cd is 0,2543 [17]. These values are lower than the values of phytoremediation factors for lavender obtained in this work.

Hem Singh et al., 2014 and Memon et al., 2021, state in research that plants grown on polluted soil, which accumulate 100 mg/kg Cd and 1000 mg/kg Pb in dry matter, can be considered hyperaccumulators [18, 19]. Considering this information, lavender plant culture can be considered a hyperaccumulator for heavy metals Pb and Cd, because the average concentration of Pb is 1477,3 mg/kg and Cd 234,2 mg/kg of dry matter of lavender plant material.

Also, lavender plant culture meets the conditions characteristic of hyperaccumulator plants [18, 19] in the study of Angelova et al., who in 2015 investigated the potential of lavender (lat. *Lavandula vera* L.) for phytoremediation of soil contaminated with heavy metals [20]. The results of the accumulation of Pb and Cd in lavender obtained by the study are compatible with the results presented in this paper.

In the study by Angelova et al., the concentration of lead in lavender root was 1566,9 mg/kg, in the stem 2157,9 mg/kg, in the leaf 5784,7 mg/kg, and in the flower 1147,3 mg/kg, and the concentration of cadmium in the root it was 160,9 mg/kg, in the stem 27,1 mg/kg, in the leaf 113,2 mg/kg, and in the flower 15,6 mg/kg dry matter. The value of the phytoaccumulation factor in the study is 1,92 for lead and 5,22 for cadmium for lavender plant culture [20].

The results of the experiment, which was realized as an integral part of this final thesis, also show high concentrations of Pb and Cd in the dry matter of lavender plant material grown on polluted soil, where the average concentration of Pb is 1477,3 mg/kg, and Cd is 234,2 mg/kg. dry matter.

Also, in the study by Angelova et al., lavender essential oil was produced and it was shown that the values of the main components of the essential oil produced from lavender grown on polluted soil meet the values prescribed by the ISO3515:2002 standard. The results indicate that the product of growing lavender on soil contaminated with heavy metals is essential oil with a very good quality, which implies a low content of camphor and a high content of linalool and linalyl acetate.

In this work, extremely high concentrations of heavy metals were obtained, because the roots inside the pots are in constant contact with the solution of heavy metals, which is in the ionic highly mobile and reactive form of the metal, which resulted in a significantly higher accumulation of heavy metals by the plant. The concentration of Pb and Cd in the dry matter of lavender is not directly related to the concentration of Pb and Cd in the soil in which the plant crops were grown. Namely, there is no linear dependence between the metal content in the soil and the metal content in the plant material, but it can be expressed as a polynomial dependence of a higher order with a high and very high correlation, that is, a distinct connection [21].

6. Conclusion

Plants that were watered with the smallest volume of heavy metal solution have the highest level of accumulation for heavy metals, and the concentration of Pb and Cd in the dry matter of lavender is not directly related to the concentration of Pb and Cd in the soil where they were grown.

The values of phytoaccumulation factors are greater than 1, so lavender can be considered a hyperaccumulator of heavy metals lead and cadmium.

In this work, extremely high concentrations of heavy metals were obtained in lavender compared to plants grown in a conventional way, due to artificial soil pollution and the limitation of space for root development in pots and the constant contact of the roots of aromatic plants with a solution of heavy metals in an ionic, highly mobile and reactive form. metal. Despite the mentioned limitations for the development of plants in pots, the lavender plant culture showed great resistance of the plant material in the artificially polluted soil in which it was grown.

The obtained values of the accumulation of heavy metals lead and cadmium of the lavender, as well as the calculations of phytoaccumulation factors, can be useful in the implementation of phytoremediation of contaminated soil in the territory of Bosnia and Herzegovina, but also more widely in the region in areas with similar climatic conditions, because lavender shows greater phytoremediation abilities compared to other plants used in research.

Aromatic plants are used for the production of essential oils, and the oil produced from aromatic plants grown on polluted soil meets the values prescribed by the standards. Also, the possibility of processing the flowers of aromatic plants into oil and the use of aromatic plants in perfumery makes it very suitable for phytoremediation of soil contaminated with heavy metals, and phytoremediation is a technology of great importance, which provides both environmental and economic benefits.

Due to the existence of suspicion that there is an influence of lead on the bioavailability of cadmium in lavender plant matter, separate watering with solutions of heavy metals is recommended in subsequent research. Subsequent research can also be provided as individual analysis of each plant part (root, stem, leaf and flower) in order to examine ability to absorb and accumulate heavy metals in different parts. Also, research can be carried out by planting lavender on sample plots near gas stations and similar potential soil pollutants with heavy metals lead and cadmium, with monitoring of heavy metal concentrations in lavender flowers that can be used for the production of essential oils, and plant crops as perennial flower beds they can rehabilitate contaminated soil over a longer period of time.

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Innovation in Education to Increase Opportunities for Climate-Smart Urban Development in the Western Balkans Region

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Abstract. Western Balkan Higher Education Institutions should improve existing education in climate-smart urban development based on green and energy efficiency, build professional and technical capacities, apply innovative teaching methods, and achieve lasting links with the non-academic sector. Motivated by this idea, the University of Montenegro and the University of Niš have jointly established a consortium consisting of six higher education institutions from EU Member States and third countries affiliated with the Programme, seven WB higher education institutions, including three universities from Bosnia and Herzegovina, then three non-academic partners from the WB region, with the support of two non-academic associate partners in the field of urban development. They received grants for implementing the Erasmus+ capacity building project entitled "Curriculum innovation in climate-smart urban development based on green and energy efficiency with non-academic sector (SmartWB)". The paper presents the project's main objectives and highlights the importance of the project on the broader social community of the Western Balkans region.

1. Introduction

The environmental impacts of modern cities go beyond their borders. The ecological footprints of cities reach far, significantly impacting the surrounding rural, regional, and global ecosystems. There are fewer and fewer areas in the world that are not influenced by the dynamics of cities. Half of the world's population already lives in cities; by 2050, two-thirds of the world's people are expected to live in urban areas [1]. Cities make up less than 3% of the Earth's surface, but there is an extraordinary concentration of population, industry, and energy use, which leads to enormous local pollution and environmental degradation [2].

In addition to numerous advantages in the social and economic sense, huge problems are generated in cities, among which environmental degradation occupies a significant place. Cities are responsible

for 70% of global greenhouse gas emissions [3], and are the most important cause of climate change, but at the same time show the greatest sensitivity to its consequences [4].

Poor air and water quality, insufficient water availability, waste disposal problems, and high energy consumption have been exacerbated by increasing population density and the demands of urban environments. Strong urban planning will be critical in managing these and other challenges as the world's urban areas grow [5].

Despite the unfavorable scenario, cities have an excellent opportunity to reduce pollution and the effects of global warming by redirecting urban energy systems, transport, and the built environment [6]. Many of the world's cities have started to switch to renewable energy, cleaner production, encourage the reduction of emissions in industrial plants, or generally use green and blue technologies and solutions. In addition to reducing pollution, the fight against climate change at the local level will also benefit residents, who will experience positive health changes by improving air quality.

The potential of cities to defend themselves against climate change is also recognized by the United Nations Environment Program (UNEP). National and local awareness is raised by organizing workshops and training activities, developing evaluation tools, and including cities in international climate change meetings. One of the main outputs of UNEP is an online knowledge center that provides information on cities and climate change. Among the information are the effects of climate change on cities and residents unless they join the fight against climate change [7].

Pollution of the urban environment and its components results from excessive environmental load and self-cleaning capacity. Environmental protection problems in urban areas are growing, especially in cities in developing countries. Understanding the key trends in urbanization likely to unfold in the coming years is critical to implementing the 2030 Agenda for Sustainable Development, including efforts to create a new framework for urban development.

As the world continues to urbanize, sustainable development increasingly depends on successful urban growth management, especially in low-income and lower-middle-income countries where the pace of urbanization is predicted to be the fastest. Many countries will face challenges in meeting the needs of their growing urban populations, including the need for housing, transportation, energy systems, and other infrastructure, as well as employment and basic services such as education and health care. Integrated policies are needed to improve the lives of both urban and rural residents while strengthening the links between urban and rural areas, building on their existing economic, social, and environmental relations.

To ensure that the benefits of urbanization are fully shared and inclusive, policies to manage urban growth should provide access to infrastructure and social services for all, focusing on the needs of the urban poor and other vulnerable groups for housing, education, health care, decent work, and safe environment.

The Western Balkans (WB) cities are generally lagging behind in the adaptation to climate change. They should plan urbanization and development according to the 2030 Agenda for Sustainable Development, especially to the 11th goal of sustainable development and communities. [8] Furthermore, there is a need to adapt the countries of the Western Balkans to the "impacts of climate change, which also requires significant political intervention in spatial organization, resource use and infrastructure" and "promotion of business climate reforms" [7]. Consequently, Western Balkans countries have already adopted national strategic documents that can be a starting point for climate-smart urban development (CSUD) and solutions.

The EU has set goals that will affect all the countries of the Western Balkans that join the EU in the sense that it is necessary to reduce greenhouse gas emissions by 40% compared to 1990 [8], increase energy consumption from renewable sources [9]; and to transition to a low-carbon economy resistant to climate change by 2050 [9]. On the other hand, it is a fact that higher education institutions in general, and especially in WB countries, are slower to adapt to the needs of society. Therefore, projects that contribute to strengthening the population's awareness and increasing adaptation to climate change are significant.

2. Motivation for the SmartWB Project

Motivated by this idea, the University of Montenegro and the University of Niš jointly founded a consortium consisting of six higher education institutions from EU member states and third countries associated with the Program, seven higher education institutions from the WB, and three non-academic partners from the WB region, with the support of two non-academic associate partners in the field of urban development. They received grants for the implementation of the Erasmus+ capacity building project entitled "Curriculum innovation in climate-smart urban development based on green and energy efficiency with the non-academic sector (SmartWB) [8].

The broader goal of the SmartWB project is to improve the quality of higher education in the area of CSUD by exchanging knowledge, experience, and knowledge, modernizing university courses in line with EU trends, and improving the level of competence and skills of teaching staff. In this regard, it is necessary to transfer innovative and newly developed technologies and knowledge from EU member states and third countries associated with the Program to a third country not associated with the Program higher education institutions in the CSUD area. EU member states, and third countries associated with the Higher Education Program have extensive experience in successfully educating CSUD students - advanced knowledge, qualified experts, modern simulation laboratories of CSUD, and rich experience in developing relations between business and academia.

To fulfill the set goals of the SmartWB project, it was necessary to investigate the need of society and the industrial sector for green workplaces and climate-smart solutions in Western Balkan countries. Research of interested parties, institutions, and stakeholders related to this issue in Western Balkans countries proved helpful in identifying and prioritizing these needs.

In this regard, the project analyzed the existing curricula and programs related to CSUD at the universities of the Western Balkans. Several target groups of stakeholders have been identified, and their needs can be summarized as follows [8]:

- Urban development students require modern and contemporary courses and teaching materials to provide the necessary knowledge and skills, resulting in rapid employability in the urban development business sector. They need practical experience and internships in companies or public institutions related to CSUD.
- Teaching staff require thematic training in advanced urban development areas, including climate-smart solutions, advanced laboratory equipment, and software to provide hands-on exercises to students. They need close collaboration with the non-academic sector, resulting in modernized courses oriented towards providing bachelors and masters with the knowledge and skills required by the industrial sector.
- Representatives of the business sector in urban development need the support of higher education institutions for the application of new technologies and solutions. They require graduates with specific advanced skills and knowledge to develop new products and services directly applied to real-time problems. For this reason, it is necessary to establish a strong relationship between the industrial sector and the university staff to support them in developing their business.
- Urban development professionals need general information on the importance and developments in urban development, emission reduction approaches, low-carbon technologies, and climate solutions. They need workshops and events to stay informed about new technologies and solutions to improve their business.
- State bodies, public municipal administration, and agencies should receive well-developed products and services based on modern approaches and professional expertise. They must have a well-developed business and academic sector in urban development and related disciplines, which will provide the capacity to meet all their needs for services and products in a highly professional, efficient, and economical manner.

3. Implementation of the SmartWB Project through Work Packages

The project will be implemented through seven work packages (WP). Every work package has special objectives (SO) that determine in more detail expected outcomes and 30 project activities labeled as tasks with deliverables. The work packages are the following:

WP1 – Project management and coordination
WP2 – Analysis of current status in climate-smart urban development
WP3 – Capacity building of WB HEIs
WP4 – Creating a technological platform
WP5 – Implementation of modernized courses and platform
WP6 – Quality assurance and monitoring
WP7 – Impact and dissemination

Vertical activities are defined by their content and type of actions undertaken for their realization and with a fixed duration in the project lifetime. Three WPs cover horizontal activities (Quality, Impact and Dissemination, and Project Management) and interact both with vertical activities and between themselves. They are active from the very beginning until the end of the project.

3.1. Project management and coordination (WP1)

WP1 covers the entire project period. It includes activities aimed at monitoring and reporting the project development from technical, administrative, and financial aspects, timing and coordination among the WPs and tasks, and managing any modification to the project work plan and task development. The leader of WP1 is Grant Holder - University of Montenegro (UoM).

All project activities will be coordinated by planned project management (WP1) that will be operational through coordination bodies (Project Management Committee – PMC and Steering Committee – SC). SC will be responsible for monitoring and guiding the project activities. PMC will coordinate the progress of each task. SC will evaluate and accept the final version of all project deliverables. PMC, SC, and Quality Assurance Committee (QAC) meetings will simultaneously be held twice a year to achieve cost-effectiveness.

The project coordinator will have a crucial role in organizing all SmartWB activities and monitoring the project deliverables' achievement. Each Consortium member will be expected to establish its local support group responsible for administration and smooth implementation of actions, project-related administration and financial issues, and submission of internal reports.

3.2. Analysis of current status in climate-smart urban development (WP2)

Before developing and implementing cooperation with the non-academic sector, the project should include an analysis of the present situation in Region 1. The analysis should indicate the level of readiness to cooperate, the user needs, and the lack of current cooperation. Identification of Western Balkans regional issues related to urban development will be done in WP2 led by University of Natural Resources and Life Sciences (BOKU).

The result of this activity will be a report on WB regional issues related to urban development that will be used for preparing a platform for knowledge and practice sharing. A three-day workshop on climate-friendly and innovative solutions will be held at BOKU, where the up-to-date topics related to climate-smart urban development will be analyzed and presented. The general overview of existing successful models of education in the field of CSUD of Programme Country HEIs and comparative analysis with the existing curricula in Partner Countries will represent the basic guidelines for the definition and development of the courses in WB countries.

3.3. Capacity building of WB HEIs (WP3)

Within the WP3, led by King Juan Carlos University (URJC), the Third country not associated with the Programme, teaching staff will be trained in Programme Country partner HEIs to acquire new practical skills in the field of CSUD.

Each of the Third countries not associated with the Programme HEI will define the local working group, which will be responsible for the modernization of university courses, collaboration with the industry sector, providing positions for students' internships, and defining training programs for students' internships. Working groups will be under the supervision and control of the Project Management Committee. Before the modernization of university courses, both teams will analyze existing curricula related to CSUD in SmartWB countries. All preliminary reports and defined programs will be prepared and analyzed at the meetings. Their short descriptions will be presented to the Steering Committee for final review and approval.

WP3 covers the infrastructure required for providing a better environment and conditions for achieving cooperation with the non-academic sector and student education. The laboratory equipment, software, and library units will be purchased to provide modern students' study programs harmonized with Programme Country best practices. The equipment will be installed in a Third country not associated with the Programme HEI's laboratories.

3.4. Creating technological platform (WP4)

European Education Initiative (UET) from Tirana will lead the WP4 and should summarise well-established solutions for climate action and adaptation to climate change, such as intelligent transport solutions for freight and passenger transport, environmental sensors, intelligent waste management, sustainable food supply, safe drinking water supply, and natural disaster risk management. These solutions should also be applied in the WB region to follow a greenhouse gas-neutral way of life. Therefore, the developed platform should be the way to the promotion of low-emission economic practices and resilient infrastructures. According to this, the questionnaire will be prepared, and a suitable survey will be undertaken. The feedback will be used to develop and implement the interactive web-based platform efficiently. Each Third country not associated with the Programme University will implement modernized courses for their students. Standardized evaluation forms will be developed and used for assessing the effectiveness and efficiency of the new or updated courses.

3.5. Implementation of modernized courses and platform (WP5)

WP5 should implement modernized university courses, at least 35 students' internships, and a platform. The self-evaluation of implemented university courses should also be undertaken. University of Sarajevo (UNSA) will lead the WP5. In this WP, students will be enrolled. Studies include teaching, learning, exercising, evaluation, and examinations. During this process, students will have the opportunity to be educated using the up-to-date equipped laboratories.

Self-evaluation of the quality of university courses will be regularly performed twice a year in the winter and summer semesters. The developed platform will be in use by different target groups, and the material will be regularly distributed.

3.6. Quality assurance and monitoring (WP6)

Quality assurance will be based on a Quality Assurance Plan and well-developed and adopted internal and external evaluation procedures focusing on the building blocks of the quality measures. The SmartWB project quality assurance and monitoring will be led by University of Niš (UNI) and performed based on the following activities: (i) Internal quality assessment will include peer reviews performed by the Quality Assurance Committee (QAC). The QAC will prepare quality reports twice a year after its meetings and send them to the SC; (ii) External quality assessment will be enabled through continuous presentation of the project activities and deliverables on the project website and their publishing in public media. The external evaluator will be subcontracting for the external evaluation of the quality of achieved project results; (iii) Inter-project coaching will also be implemented. Consortium members will contact the members of ongoing and/or completed Erasmus+ projects in similar fields to use their accumulated expertise and undertake a peer review.

Standards and Guidelines for Quality Assurance in the European Higher Education Area, developed by ENQA (European Association for Quality Assurance in Higher Education), adopted by the Bologna

Process Ministers in 2005, will be taken as reference, as well as the key quality assurance principle of continuous improvement.

3.7. Impact and dissemination (WP7)

The goal of this work package is an efficient dissemination and exploitation of project results and products not only in project partner countries but also outside of them. Dissemination will raise the relevance of strengthening the relations between the Third country not associated with the Programme HEIs and the non-academic sector for high-level education in the field of climate-smart urban development, especially in technology-driven courses, to increase awareness about the project and its results within its main target groups (representatives from industrial sector, teachers, students, professionals and other representatives from academic and non-academic institutions, representatives from government bodies and local administration) and to assure that the project results will be maintained and further developed after the completion of the project. Project dissemination will involve institutional, national, and international levels of activities. It will be focused on promoting the project itself, its objectives, and achieved results and participants and raising awareness of target groups and the general public about the potential benefits of the project results. Special attention will be paid to promoting emission-reduction approaches and low-carbon technologies. The WB partners will organize promotions for WB non-partner HEIs using roundtables and promotional events. In the long-term perspective, increasing the public and state authorities' awareness of the significance of climate-friendly solutions and the need for green jobs in urban development is necessary. This goal will be achieved mainly through distributing brochures and leaflets to provide all relevant project information to interested stakeholders, as well as to publish information about SmartWB in mass media and direct contact at the organized promotional events.

4. Conclusions

Considering the importance of the academic community in connecting the public-private sector and educating future professionals who will face urban development problems, a particular segment of the project is devoted to the modernization of teaching curricula. The modernized higher education institutions of the Western Balkans will not only transfer knowledge but also create economic and social value by strengthening their capacities and providing better working conditions for the next generation. Promoting innovation and entrepreneurship will establish a stronger connection and cooperation with the private sector.

The Western Balkans countries are developing and striving for their capacities in climate-smart urban development to be equal to those of other countries in the European market. For this reason, reforms of Western Balkan university programs should follow regional development and European directives and initiatives. Given that the professional and academic preparation of experts in this field begins at the respective universities, academic staff have a high scientific and research responsibility for actively providing knowledge, skills, and competencies to ambitious experts in climate-smart urban development.

Guided by this idea, the SmartWB project consortium was formed because the higher education institutions of the Western Balkans recognized the need to invest in upgrading existing capacities in CSUD, improving technical innovations and equipment, infrastructure, information, and technological systems based on EU standards, and constantly strengthening staff competencies through education and training system.

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Acknowledgments
The presented research is a part of the Erasmus+ project: "Curricula innovation in climate-smart urban development based on green and energy efficiency with the non-academic sector (SmartWB)", ref. No. 101081724 — SmartWB — ERASMUS-EDU-2022-CBHE.

Analysis of air quality in the area of the city of Bihać

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Abstract. This paper describes the air quality in the area of the city of Bihać with regard to the crucial pollutants observed during monitoring. These are the most common: CO, NO_2, SO_2, $PM_{2,5}$, PM_{10}, and O_3. With regard to the database submitted by the Federal Hydrometeorological Institute, an analysis of the mean value of the concentrations of each pollutant by month was carried out, and the maximum daily values there of were determined. Results and pollutant concentration values are presented in graphs. In the first part, some general concepts, such as the composition and properties of air, air pollution, and its impact on humans, are defined. The paper also describes the parameters we observe during monitoring as well as the limit values of pollutants in the Federation of Bosnia and Herzegovina that are prescribed and which are extremely important to us during the analysis itself.

1. Introduction

The development of many industries and the modernization and introduction of new technologies are putting increasing pressure on the planet. There are many forms of pollution; however, the one that is extremely poorly understood is air pollution. Air is a very important factor in human life because it forms the basis of it. Despite all the important properties of clean air for humans, too little attention is paid to its protection and monitoring. [1] Air monitoring is the continuous monitoring of all pollutants present in the air in order to ensure adequate air quality. However, it is not carried out responsibly. This is confirmed by the fact that more than 90% of the population of European cities is exposed to a high concentration of pollutants in the air at very high values compared to the limit. Today, air pollution is not only a problem at the local level but also at the global level because pollutants released in one area can reach far away from their primary source and pollute a wide area. Floating particles are considered a very dangerous pollutant, especially $PM_{2.5}$, which, according to some statistical data, is estimated to be able to reduce a person's lifespan by even more than nine months [2]

2. Composition and properties of air

Radiated air is a mixture of gases that surround the Earth and form a gaseous envelope (atmosphere). Air is a very important environmental factor because it forms the backbone and basis of all life on Earth. This is confirmed by the fact that a person can survive only a few minutes without air, while without water and food, he can survive for several days or weeks. Likewise, the fact that a person inhales about 20,000 litres of air every day speaks of its immense importance [3]. Air is mostly made up of nitrogen, then oxygen, and the rest of the gases such as methane, argon, carbon monoxide, etc. Oxygen, as a product of the photosynthesis of green plants, is introduced into the organism by means of the respiratory system, and carbon dioxide is expelled, which the plants reabsorb and use in the

process of photosynthesis. In this way, the natural balance between all other environmental parameters is maintained. Clean air is a gas without colour, taste, or smell.

3. Sources of air pollution

Air pollution is a major problem today, caused by industrialization and the use of modern technologies. It can be defined according to the classic definition contained in the Law on Air Protection of the Federation of Bosnia and Herzegovina as the direct or indirect introduction of substances into the air by humans, which results in such harmful effects that endanger human health and cause damage to life resources as well as ecosystems and material goods. Today, the quality of the air is greatly impaired due to the presence of an increasing number of sources of pollution, both natural and anthropogenic. A source of pollution is considered to be any source of the release of pollutants into the air. Sources of pollution cause many harmful consequences, both for humans and for the entire environment, i.e., our biosphere. Although compared to anthropogenic sources, natural sources are much rarer, they are not negligible. Some of them are forest fires that can be caused by lightning strikes or some other natural impact, then evaporation during organic decomposition, desert dust carried by the wind, and the like. Anthropogenic sources are increasingly common sources of pollution, such as traffic or industrial production, whose negative impacts lead to disturbances in the natural balance. [1, 4]

4. Air quality monitoring in the federation of Bosnia and Hercegovina

Air quality monitoring in the Federation of Bosnia and Herzegovina is the responsibility of the Federal Hydrometeorological Institute and competent cantonal authorities, as well as local self-government units, which are obliged to provide network stations, i.e., measuring points for air quality monitoring and accompanying analyses. The Federal Hydrometeorological Institute collects data from the stations of the Federal Network and other networks in the Federation of Bosnia and Herzegovina. The automatic station in the city of Bihać started operating in the middle of 2021. [5] In addition to the classic measurement of the level of pollutants present, the type of biological monitoring is becoming more common with the aim of improving the classic types of monitoring and assessment of the state of the environment, where bioindicator plants are introduced to assess the state of individual species as well as the entire ecosystem.

Table1. Limit values, upper and lower assessment limits, tolerance values, and alarm thresholds [6] (All listed table values are expressed in μg/ m^3, except for the value for CO, which is expressed in mg/ m^3).

Polutant	Averaging time	Limit value	Upper rating limit	Lower rating limit Tolerance limit	Tolerant limit	Tolerant value	Alarm threshold	Minimum data availability
SO_2	1h	350	-	-	105	380	500	75%
SO_2	1 day	125	75	50	-	125	-	90%
SO_2	1 year	50	-	-	-	50	-	90%
NO_2	1h	200	105	75	70	220	400	75%

NO_2	1 day	85	32	26	28	93	-	90%
NO_2	1 year	40	-	-	14	44	-	90%
CO	8 hours	10	7	5	3	10	-	75%
CO	1 day	5	-	-	9	6	-	75%
CO	1 year	3	-	-	-	3	-	90%
PM_{10}	1 day	50	35	25	18	56	-	75%
PM_{10}	1 year	40	28	20	6	41,5	-	90%
$PM_{2,5}$	1 year	25	-	-	-	26	-	90%
O_3	8 hours	120	-	-	-	-	240	75%
Benzene	1 year	5	3,5	2	2,7	5	-	90%

The air quality index for the Federation of Bosnia and Herzegovina was prepared by the Federal Hydrometeorological Institute. It is actually a parameter that combines data such as CO, O_3, $PM_{2.5}$, PM_{10}, SO_2, and NO_2 into a single value. Air quality index values range from 0 to 500. Air quality values up to 100 are considered satisfactory.
For ease of study, the air quality index is divided into several groups, namely:
good (0-50)
moderate (51-100)
unhealthy for sensitive groups of people (101-150)
unhealthy (151-200)
very unhealthy (201-300)
dangerous (301-500).

5. Analysis of air quality in the city of Bihać

The meteorological station in Bihać is located 250 meters above sea level. In order to determine the meteorological data as precisely and accurately as possible, it must be located in such an environment and at such a height. In the city of Bihać, a mobile station for measuring air quality was installed in the meteorological station in mid-2021, and in this way, monitoring of air quality in this area was made possible. This device is a donation from the Swedish Agency for International Development and Cooperation as part of the "IMPAQ" project implemented by the Swedish Environmental Protection Agency (SEPA). By putting the measuring station into operation, the city of Bihać was placed on the federal map of air quality monitoring and also on the map of the European Environmental Agency. The territory of the Federation of Bosnia and Herzegovina is mostly covered by measuring stations for air quality, and the data can be read electronically on the official website of the Federal Hydrometeorological Institute. The measuring station in the city of Bihać reads the concentrations of pollutants, namely: CO, O_3, $PM_{2.5}$, PM_{10}, SO_2, and NO_2. In addition, it also measures pressure, temperature, and air humidity.

Figure 1. Interior of the Air Quality Measuring Station (author Hana Demirović).

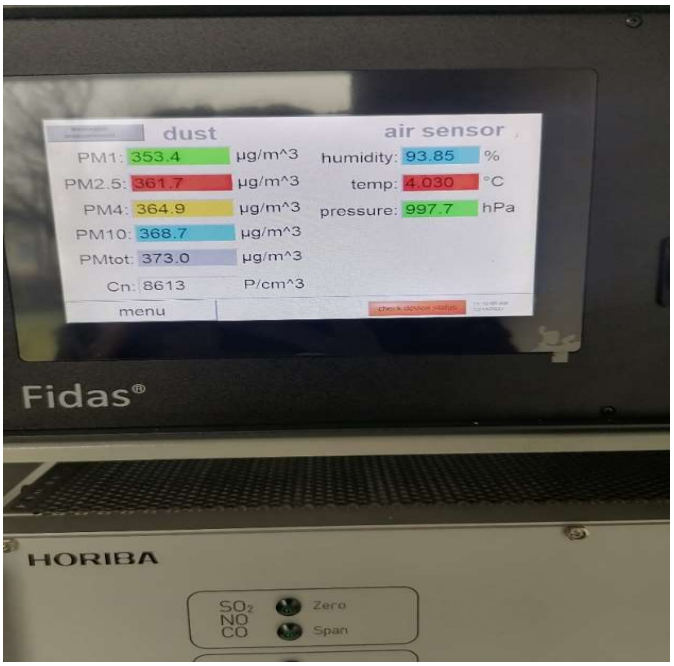

Figure 2. Display of the read results of air parameters (author Hana Demirović).

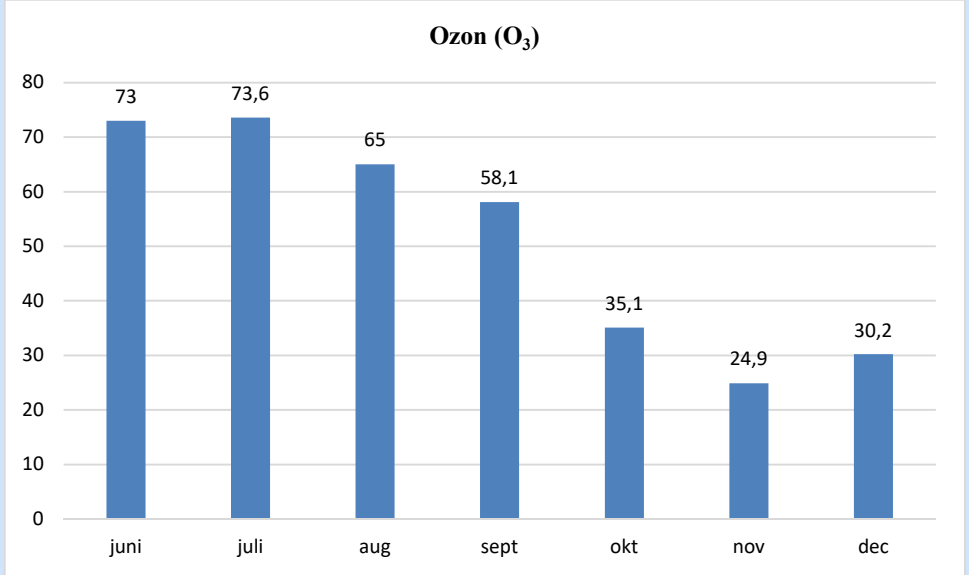

Figure 3. Measured mean values of ozone concentration by month (µg/ m^3).

The measuring station in Bihać started operating in June 2021. Measurements were taken from 00:00 to 23:00 every day of the month. The mean values of these measurements were taken for each month and presented on the graph. Ozone concentrations in the air depend on both natural and anthropogenic conditions, so monitoring and regulating the concentrations of this gas is much more difficult compared to other pollutants. An increased concentration of ground-level ozone can be expected in mountainous areas, in areas with intense traffic, and in industrial areas. [7] The high values of ozone are the result of the presence of its precursors, i.e., nitrogen oxides and volatile organic compounds (VOC), in the air. Elevated concentrations of ground-level ozone are common in the warmer part of the year (especially in summer), as evidenced by Graph 1. The highest mean annual limit value for ozone is not defined, while the daily limit is 120µg/ m^3. The highest measured daily concentration in the city of Bihać during the past year was 108µg/ m^3 (in the month of July) and did not exceed the limit values defined for this pollutant.

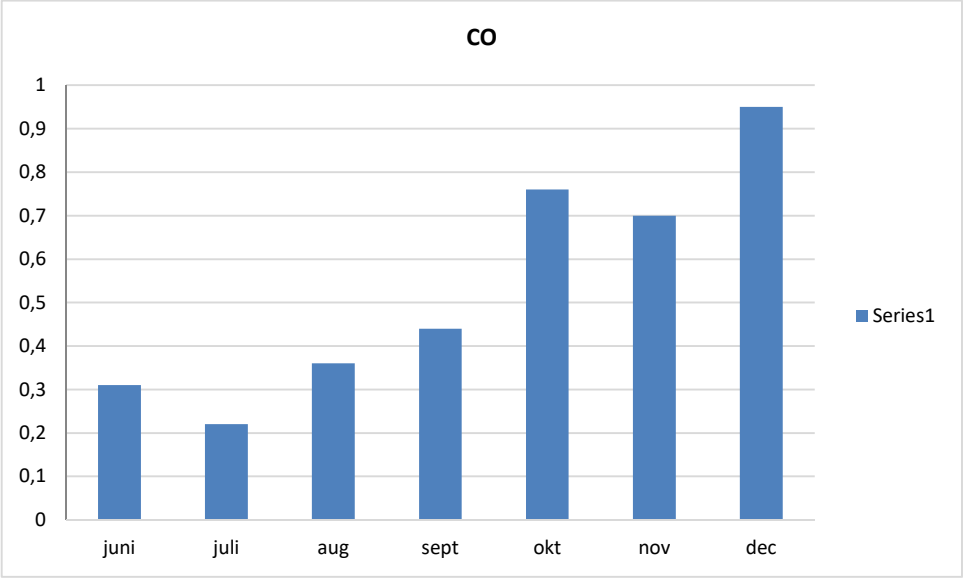

Figure 4. Measured CO concentrations by month (mg/ m^3).

Carbon monoxide was also monitored at the measuring station in Bihać last year. The values of this parameter are expressed in mg/ m^3 and represent the average value for each month of the past year since the beginning of the operation of the measuring station. Looking at the graph, we can see a proportional increase in value from the summer period to the winter period. The highest daily concentration measured at the measuring point in the city of Bihać in the past period was 2.8 mg/ m^3 (in the month of December). The highest measured hourly value was 5.1 mg/ m^3.

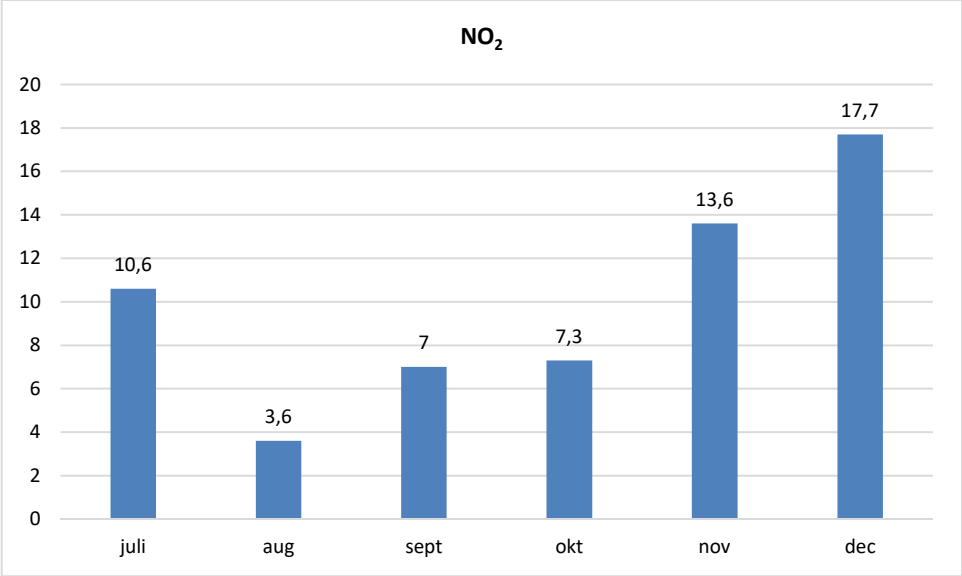

Figure 5. Measured concentrations of mean NO_2 values by month (µg/ m^3).

Nitrogen dioxide concentration has also been measured at the measuring station in the city of Bihać since June. The limit value of the mean annual concentration of this parameter is 40 µg/ m^3, and the daily limit value is 85 µg/ m^3. The highest daily concentration measured in the city of Bihać was 36 µg/ m^3. The limit hourly concentration for this parameter is 200µg/ m^3. In Bihać, the highest measured value is 79 µg/ m^3, which is quite satisfactory. There were no daily or hourly violations recorded in the past year in the city of Bihać.

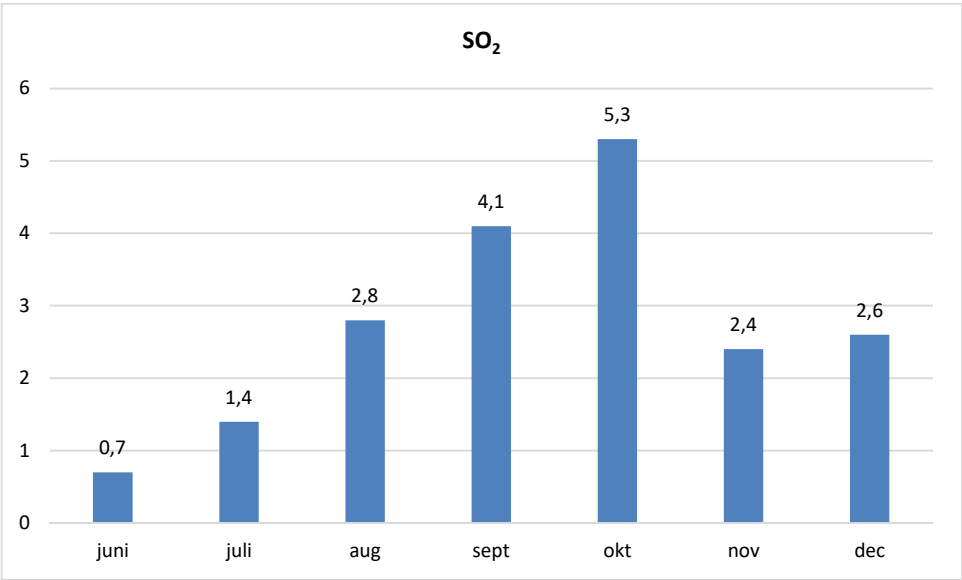

Figure 6. Measured daily mean values of SO_2 concentration by month (µg/ m^3).

The limit value of the mean annual concentration of SO_2 is 50 µg/ m^3. During the past year, measurements were made at 25 measuring stations. In the city of Bihać, measurement began in June, and values were read every hour. The daily mean values for each month are defined, and we see that the measured values are well below the limit values. The permitted number of exceeding the daily limit value of 125 µg/ m^3 is three times during the year. The highest daily mean concentration in 2021 measured in Bihać is 9µg/ m^3 measured in October, and the highest hourly value is 49µg/ m^3, which is still in line with the limit values for SO_2.

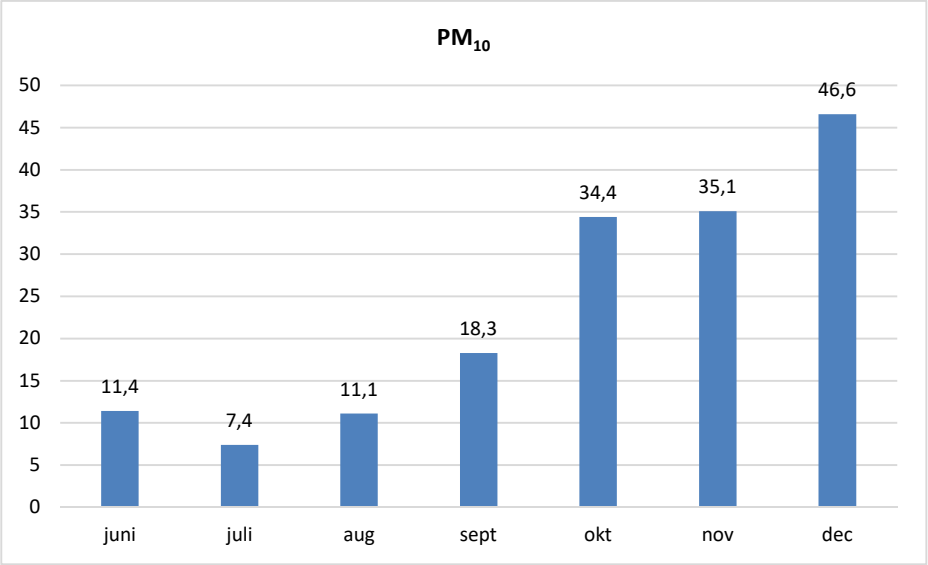

Figure7. Measured mean values of PM_{10} particle concentrations by month (µg/ m^3).

The limit value of the average annual concentration of PM_{10} particles is 40 µg/ m^3. The daily limit value is 50 µg/ m^3. The hourly limit value for this parameter is not defined. The highest daily concentration measured in the area of the city of Bihać is 52 µg/ $m^3$and exceeds the permitted limit value. The highest daily value was read in the month of December.

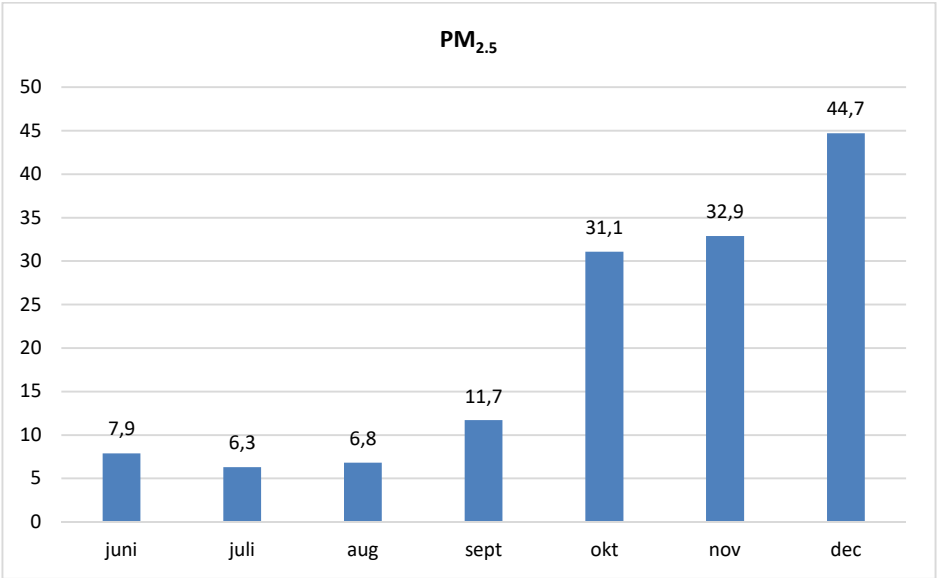

Figure8. Measured mean values of $PM_{2.5}$ concentrations by month (µg/ m^3).

The limit value of the average annual concentration of $PM_{2.5}$ is 25 μg/ m^3. The daily and hourly values for these particles are not defined. The ratio of $PM_{2.5}$ fractions within PM_{10} often varies with regard to the summer and winter periods, and if the PM10 concentrations are elevated and above the permitted values, this automatically alludes to elevated $PM_{2.5}$ fractions as they are fractions of the same pollutant but of different diameters. The highest measured daily value of these particles in the area of the city of Bihać in 2021 is 48 μg/ m^3, in the month of December.

6. Conclusion

In the past year 2021, monitoring was carried out at a total of 26 automatic measuring stations, including the station in the city of Bihać, which started operating in June 2021. Most of the stations are under the jurisdiction of the Federal Hydrometeorological Institute, with which they are directly connected so that data on measured pollutant values and concentrations are automatically forwarded. In the coming period, the Federal Hydrometeorological Institute plans to cover and establish a network of stations for measuring air monitoring in areas where they have not yet been established. After reviewing the data submitted by the Federal Hydrometeorological Institute, the following was observed:

- Increased concentrations of floating particles were observed in the area of the city of Bihać, but also in almost all parts of the Federation of Bosnia and Herzegovina. Especially in the winter, these concentrations are significantly higher. Just because the concentrations of $PM_{2.5}$ particles are elevated, the concentrations of PM_{10} particles are also elevated because they are the same pollutant, only with different diameters. These particles are an integral part of the smoke, soot, etc., so their increased concentration is justified during the winter months when combustion processes and the release of smoke into the atmosphere are much more present, as is the appearance of smog.

-Ozone concentrations are in accordance with the permitted and prescribed values in the area of the city of Bihać. They are slightly elevated during the summer period; the highest measured daily concentration in the month of July is 108 μg/ m^3, but still in accordance with the prescribed limit values. High concentrations of ground-level ozone occur frequently in the summer months, especially in mountainous areas and highly populated and busy places. As a pollutant, ozone is most often the result of anthropogenic and various other activities.

- Carbon monoxide concentrations are also within the limit values during all observed measurement periods. The highest measured daily concentration was 2.8 mg/ m^3, measured in the month of December, which is still within the maximum allowed concentration for this parameter. There is a visible increase in CO concentration from summer to winter.

- Concentrations of nitrogen dioxide that were measured in the area of the city of Bihać during the past year are also within the limits of limit values. They slightly increased during the months of June, November, and December, unlike other months.

- Sulphur dioxide concentrations measured in the area of the city of Bihać are also within the limit values. This gas is most often a product of burning fossil fuels in motor vehicles. Higher concentrations were observed during the months of September and October, and at the end of the year, they tend to fall again.

After the analysis, we can conclude that the air quality in the area of the city of Bihać is at a significantly high level. This is also contributed to by the fact that the city does not have developed heavy industries, which would greatly harm the air quality itself as well as the environment.

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The importance of introducing recognizable marks and certificates for Bosnian-Herzegovinian agricultural and craft products and processes in order to promote it as tourist offer

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Abstract. As part of its food quality policy, the European Union promotes three types of quality marks for agricultural and food products: protected designation of origin, protected geographical origin and traditional specialty guaranteed (TSG). In BiH, the process of protection of marks of origin and protection of marks of geographical origin and the procedure of protection of marks of guaranteed traditional specialty food products, as well as the registration process itself, is carried out by the Food Safety Agency of BiH at the level of the European Union. In this paper, we have focused on guaranteed traditional specialties, which covers agricultural and food products that are produced using traditional raw materials or produced by traditional methods or that have a traditional composition, without restrictions on the geographical origin of the product. Recently, consumers have shown an increasing interest in quality and traditional products. therefore, as a result, demand is created for agricultural products and foodstuffs with specific, recognizable characteristics, especially those related to their geographical location and method of production. As semi-valuable food products are part of the tourist offer of the destination, in this paper we will present the significance of the introduction of the guaranteed traditional specialty label for agricultural and food products in Bosnia and Herzegovina. In addition, the procedure for protection of the mark, certification and verification of compliance with the manufacturer's specification for the two products Krajiška omač and Krajiška tarhana will be presented. As part of its food quality policy, the European Union promotes three types of quality marks for agricultural and food products: protected mark of origin, protected geographical origin and Traditional specialty guaranteed (TSG). In Bosnia and Herzegovina, the procedure for protection of marks of origin and protection of marks of geographical origin and the procedure for protection of marks of traditional specialty guaranteed food products, as well as the registration procedure itself, is carried out by the BiH Food Safety Agency at the level of the European Union. In this paper, we have focused on the traditional specialty guaranteed, which covers agricultural and food products that are produced using traditional raw materials or produced by traditional methods or that have a traditional composition, without restrictions on the geographical origin of the product. Recently, consumers have shown an increasing interest in quality and traditional products, and as a result, there is a demand for agricultural products and foodstuffs with specific, recognizable characteristics, especially those related to their geographical location and method of production. As semi-valuable food products are part of the tourist offer of the destination, in this paper we will present the importance of introducing the

label of traditional specialty guaranteed for agricultural and food products in Bosnia and Herzegovina. In addition, the trademark protection procedure, certification and verification of compliance with the manufacturer's specification for two products, "Krajiška omač" and "Krajiška tarhana", will be presented.

1. Introduction

The goals of the first quality labels in Europe are primarily intended to protect manufacturers from misuse of product names and to increase their income through price premiums, so that a greater number of different features and labels appear on the market with the aim of informing and restoring consumer confidence. The designation of geographical indication of food products is based on strict regulations in Europe, in order to protect producers from unfair competition and to guarantee consumers the origin of the product. The main quality indicators are usually related to the brand, price, appearance, and the market in which the product is sold. Geographical indications and designations of origin are industrial property rights that describe a product that originates from any region or can be attributed to any region due to its quality, reputation or other characteristics. Indications of geographical origin and indications of traditional specialties are important instruments of the product quality policy of the European Union. The European Commission, as part of its food quality policy, has adopted schemes according to which quality labels can be assigned to products that meet certain conditions. In the context of developing countries, a greater number of initiatives that tried to protect and valorize traditional and territorial food products were promoted by international organizations, such as the World Bank and FAO, and by national authorities. [2] The EU, which has the largest number of agricultural and food products protected by geographical indications, has a well-developed system of regulation of geographical indications (suigeneris), based on three types:

- Protected designation of origin - PDO: covers agricultural and food products that are produced, processed and prepared in a specific geographical area using recognized knowledge and experience.
- Protected Geographical Indication - PGI: covers agricultural and food products that are closely related to the geographical area. At least one of the stages of production, processing or preparation takes place in that area.
- Guaranteed traditional specialty - TSG: emphasizes the traditional character, either in the composition or the method of production. [3]

Council Regulation (EEC) no. 2082/92 of July 14, 1992 on certificates of special properties of agricultural and food products defines certificates of special properties, and the term "guaranteed traditional specialty" was introduced by Commission Regulation (EEC) no. 1848/93 prescribing detailed rules for the application of Regulation (EEC) no. 2082/92. Certificates of special properties, more often referred to as "guaranteed traditional specialties", meet consumer demand for traditional products with special properties.[4] The label "guaranteed traditional product" as a quality scheme aims to ensure a regime of protection of traditional food products of a specific character. In this case, the protected food product does not have to be associated with a certain geographical area, the food product must have a "specific character" and that its raw materials, methods of production or processing must be "traditional". [5] The TSG mark may gain more importance as a market mark. However, they can still play a significant role as tools aimed at connecting the names of traditional products with their original recipes and production methods, thus contributing to the preservation of relevant parts of the gastronomic heritage of the area, and the promotion of gastrotourism.[6]

2. Guaranteed traditional products in Bosnia and Herzegovina

The area of protection of food products with guaranteed traditional specialty labels in Bosnia and Herzegovina is regulated by the Ordinance on quality systems for food products ("Official Gazette of

BiH", number 90/18), which is based on the Law on Food ("Official Gazette of BiH", number 50/04). The aforementioned legislation is harmonized with COUNCIL REGULATION (EC) no. 509/2006 of May 20, 2006 on agricultural and food products as guaranteed traditional specialties. [7] Only the Association has the right to submit a request for registration of a guaranteed traditional product. An association can apply for registration only for agricultural or food products that it produces or procures. A product is considered "traditional" if it has been proven to be sold or consumed unchanged for at least 30 years. Recognition as GTS can only be requested for food and agricultural products. In Bosnia and Herzegovina, the registration of products with the label "guaranteed traditional specialty" is carried out by the Food Safety Agency of Bosnia and Herzegovina. The process of protecting the marks of guaranteed traditional specialty food products can be registered on the territory of Bosnia and Herzegovina, but also at the level of the European Union.[8]

2.1. The registration process

The registration process began with the submission of an application for the registration of a guaranteed traditional specialty, submitted by an interested group or association of producers. One of the key documents in the process is the creation of a product specification that includes the name proposed for registration in the languages in official use in Bosnia and Herzegovina, a description of the product including its main physical, chemical, microbiological and organoleptic properties, which prove its specific character needed for identification products; a description of the production method that the manufacturer must follow, including, where appropriate, the nature and properties of the raw materials or ingredients used and the method of preparation of the product, and the key elements that determine the traditional properties of the product. Based on the procedure for registration of the mark, the Food Safety Agency of BiH issues a decision on entry into the Register of Guaranteed Traditional Specialties and the mark is published in the "Official Gazette of BiH". and on the Agency's website. Any interested person can ask the Agency to see the specification of a product that has been recognized with special properties and assigned a label. [9]

2.2. The process of compliance with the product specification and official control

For the protected mark of guaranteed traditional specialty used to mark the products, the verification of compliance with the specification is carried out by one or more control bodies that act as bodies for assessing compliance for products authorized by the Council of Ministers of Bosnia and Herzegovina, at the proposal of the Food Safety Agency. Bodies for assessing compliance with the manufacturer's specification must be accredited by the Institute for Accreditation of Bosnia and Herzegovina or another international body authorized for accreditation according to the requirements of the BAS EN ISO/IEC 17065 standard. This international standard contains requirements for competence, consistent work and impartiality of product certification bodies, processes and services.[10] The procedure for confirming compliance with the product specification for a guaranteed traditional specialty is carried out after the adoption of a decision on the protection of a guaranteed traditional specialty, and it is carried out by an authorized conformity assessment body. The control plan is drawn up on the basis of the product specification for protected marks of guaranteed traditional specialty and must be approved by the Food Safety Agency. The body selected for conformity assessment is obliged to create a control plan and submit it for approval to the Food Safety Agency within 60 days from the date of adoption of the decision on the protection of the name of the protected mark of guaranteed traditional specialty. This request must be submitted by every producer of a product with the name protected as a guaranteed traditional specialty, that is, the user of the label, as well as every participant in the chain of production, processing and distribution specified in the product specification. Upon completion of the conformity confirmation procedure, the conformity assessment body issues a certificate of conformity of the product to the user of the label, who submits it to the Food Safety Agency. [11]

2.3. Elements that determine the traditional character of the product

Elements that establish the traditional character of the product, each GTS specification must establish the traditional character of the product being registered. It is therefore important to understand how this element is treated in the specifications. In order to achieve this result, five necessary factors were

adopted in the assessment to prove the assessment: (1) cultural history; (2) socioeconomic history; (3) market reputation based on the traditional character of the product; (4) traditional know-how in the selection of ingredients and; (5) traditional knowledge in the method of production. Each of these factors is described below. [12] The cultural-historical factor takes into account cases where the traditional character of the product is proven by describing the history and cultural importance of the product. The description of the socio-economic related factor indicates the influence that, according to the specification, the product had on the development of the area of production in the social and economic sense. Market reputation based on the traditional character of the product and this factor takes into account the market success, consumer perception and international recognition of the product. Traditional knowledge in the selection of ingredients.[13] Some products justify their traditional character by referring to long-standing practice related to the selection of ingredients. For example, in the specification for the Slovenian *"Idrijski žlikrof"*, it is emphasized that the choice and selection of ingredients is one of the foundations of the traditional character of the product.[14]

Traditional knowledge in the method of production is a factor related to specifications that expressly claim that the method of production has a traditional character. For example, the specification for *"Mozzarella"* states that "Mozzarella cheese is a product of well-established fresh cheese production technology, part of the Italian dairy tradition".[15]

2.3. Advantages and benefits of using the label guaranteed traditional specialty

It is generally known that producers want to increase the market value of traditional agricultural or food products that are clearly different from similar agricultural or food products due to their inherent characteristics. The use of the mark guaranteed traditional specialty is a voluntary system, which enables business entities to acquaint the general public with the quality of an agricultural or food product. In addition, it provides a guarantee that it is high-quality and safe for use, as well as proof that it is a product with special properties.[16] In the context of doing business with products labeled as a guaranteed traditional specialty, other accompanying entrepreneurial activities appear compared to the usual ones. One of the most famous examples is tourism with an initiative such as food roads, supply of local products and dishes in agritourism, a traditional specialty in the gastronomic offer, and new forms of promotion of the destination and tourist offer. In addition to shopping and spending activities in local souvenir shops, food stores and restaurants, tourists are offered products with the GTS label, and based on this, income for the local community is increased. Given that products with the label are guaranteed to be traditional specialties with higher selling prices as a brand, this can significantly contribute to the creation of local employment, especially in rural areas.[17] In addition, products with the label of a traditional product can lead to significant spin-off effects, namely in tourism, catering and gastronomy. In addition, it contributes to the creation of a regional brand, because it encourages a sense of belonging and originality. [18]

3. "Trahana" and "Krajiška omač" are the first registered guaranteed traditional specialties in Bosnia and Herzegovina

Although the Agency for Food Safety in Bosnia and Herzegovina carries out numerous activities to promote the importance of protecting products with geographical and traditional indications, the number of protected products is not at an enviable level. There are also numerous grants, both national and international, that support and support these activities. The first two products in BiH were registered in May 2023 as guaranteed traditional specialties, and they are the products *"trahana*" and "*Krajiški omač*". The bearers of the label are the producer association "*Stari-novi okus*", which operates under the Chamber of Crafts of the Una-Sana Canton. These specialties are traditional products produced in households in the northwestern part of Bosnia and Herzegovina. *Krajiški omač* is pasta with eggs that is cut in the form of noodles, and the word *omač* comes from the Turkish word *omač* and has two meanings: a type of home-made square noodles for soup/broth and an old dish that was eaten for breakfast. Dried pasta with eggs is made in the form of wide noodles, which are cooked in salted water until a soft consistency is reached. It can be served as an independent dish with the addition of cream or as a side dish to meat sauces. *Trahana* is obtained by fermentation of dough obtained by mixing wheat flour, water and yeast, or only flour and water, manually processed by tearing and rubbing through a

sieve. In this way, a specific granular form of pasta is obtained, which is dried in the sun. The original word is from the Persian language *tarhana*, but if we compare the form of *tarhan* and the form of *trahana* in northwestern Bosnia, we notice that in this second word the sounds a and r have been shuffled, that is, they have changed their positions. This is due to the fact that the people in the northwestern part of Bosnia connected the word *tarhana* with the word *trati*, as one of the procedures for making pasta. It is used to prepare soup and broth called *trahana.*

4. Conclusion

Manufacturers protect products guaranteed by traditional specialties only in the event that the name of the product has become generic, e.g. *trahana*, both on the domestic market, in relation to the country of origin, and outside it (the EU common market. Products that are guaranteed by GTS traditional specialties have their own logos under which are placed on the market. They are usually joint trademarks, associations of producers and other entities that are connected by the process of production or distribution of these products. Guaranteed traditional specialties are not subject to strict restrictions such as the transfer of rights, licenses, pledges or franchises. In Bosnia and Herzegovina, there is a legal basis for the registration of products with a guaranteed traditional specialty. Their registration would standardize the production process of such products and thereby ensure the quality of the products. They must also be subject to continuous quality control and certification of the production process. The production of products with added value as guaranteed traditional specialties in BiH is currently at a very low level, considering that the first batch of products *"trahana"* and *"Krajiški omač"* were registered in the register only in 2023. Guaranteed traditional specialties will receive full material affirmation through a tourist offer in which the price of these products is many times higher than the market value, and they will contribute to the branding of the trust destination through the promotion of gastrotourism.

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