

**XII INTERNATIONAL
CONFERENCE
QUALITY SYSTEM
CONDITION FOR
SUCCESSFUL BUSINESS
AND COMPETITIVENESS
PROCEEDINGS**



KOPAONIK, May 15-17, 2024

**ASSOCIATION FOR QUALITY AND STANDARDIZATION OF
SERBIA**

XII INTERNATIONAL SCIENTIFIC CONFERENCE

**QUALITY SYSTEM CONDITION FOR
SUCCESSFUL BUSINESS AND
COMPETITIVENESS**

PROCEEDINGS

Kopaonik, 15th–17th May 2024

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FOREWORD

I proudly greet you on behalf of the organizing committee of the 26th National and 12th International Scientific and Expert Conference entitled "QUALITY SYSTEM AS A CONDITION FOR SUCCESSFUL BUSINESS OPERATION AND COMPETITIVENESS." This conference represents a significant event for all of us, as it brings together experts in the field of quality systems to exchange knowledge, experiences, and best practices.

The conference is the result of collaboration with numerous institutions and organizations, as well as co-organizers, donors, and partners, who have collectively contributed to the richness of topics and the diversity of approaches.

The co-organizers of the 26th National and 12th International Scientific and Expert Conference are::

- Faculty of Veterinary Medicine, Belgrade*
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We are organizing the scientific expert convention this year with support of

- Ministry of Economy of the Republic of Serbia*
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The media sponsors of the conference are the magazine Kvalitet & Izvrsnost and the Portal Kvalitet.

The main sponsor of this conference is Trajal Corporation from Kruševac.

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There is no doubt that we can expect a series of interesting topics and discussions during the conference. A large number of papers covering current and relevant topics have been submitted..

- Quality system condition for successful business and competitiveness*
- Improvement of quality infrastructure*
- Development and establishment of management systems in theory and practice*
- Food safety*
- Engineering and quality management*
- Knowledge management*
- Global quality*
- Industry 5.0*
- Measurement, control, and quality in production*

- *Informal education*
- *Information system in the function of management system development*
- *Quality improvement tools*
- *etc.*

Panel sessions with prominent panelists and moderators promise rich content and valuable discussions:

- 1. Artificial intelligence as a key element in strengthening business and competitiveness*
- 2. Considering climate change in organizational management systems using tools such as ISO 22301 and the UNDRR tool for developing business continuity plans for analyzing and assessing climate risks*
- 3. New challenges in the field of occupational health and safety - interpreting occupational health and safety laws*

As well as a round table discussion on the topic: HOW TO IMPROVE THE QUALITY INFRASTRUCTURE IN SERBIA

On this occasion, we express our gratitude to all authors, co-authors, co-organizers, sponsors, donors, and media sponsors who have enabled the realization of this conference. In order to promote continuous improvement, this year we are awarding prizes to deserving individuals as well as prizes for the "Training for Business Quality" competition.

Your presence at this conference contributes to its success and significance. We believe that you will enjoy not only the professional discussions but also the social activities such as the exhibition football match, darts competition, welcome drinks and cocktail, and the gala dinner with wonderful music that will provide you with additional pleasure in the pleasant atmosphere of Kopaonik.

Let this conference inspire us for further work and development, and may we emerge from it enriched with new knowledge and contacts.

Warm regards and welcome to the largest conference dedicated to improving quality infrastructure..

Enjoy the beauty of the new knowledge.

Chairman of the organizing committee

Prof. dr Zoran Punoševac

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SOME QUALITY PARAMETARS OF APPLE JUICE CONCENTRATED BY FREEZING

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Teodora Marković, master student²

Prof. Jovana Rakić, master student ³

Abstract: : In this study we apply simple freezing and thawing method to concentrate apple juice, in two consecutive freezes, by simultaneously freezing both the concentrate and the diluted juice. The apple juice was frozen in a static freezer, for 12 hours, and thawed at ambient temperature until half of the initial volume is collected. After first and second concentration stage feed juice reached total solids value of 16,17g/100g and 23,3 g/100g, respectively. Concentration of organic acids increases from 5,55 g/L to 7,55 g/L and 11,77 g/L, after two steps of freezing respectively. The original juice had a pH value of 3,34 and a slight reduction was obtained in the concentrated product. It has been shown that apple juice can be concentrated using a simple cryoconcentration technique.

Keywords: Concentration, Freezing, Apple juice

JEL Classification: L66

1. INTRODUCTION

Liquid foods gneraly have a low solid content, which usually ranges from 8% to 16%. Partial or whole water content removal is often necessary step in liquid food processing in order to reduce weight or volume and consequently cost of packaging, storage, transportation. The most popular methods of fruit juice concentration are evaporation, reverse osmosis and freez concentration. High temperature used in evaporation processe cause degradation of physicochemical properties and heat-labile bioactive compounds, reducing health benefits and nutritional value of liquid food ⁴. Reverse osmosis is

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⁴ Deshpande S.S. et al., Freeze concentration of fruit juices, CRC Critical Reviews in Food Science and Nutrition, Volume 20, Issue 3,1982, pp.173-247

membrane-based fruit concentrate producing technology, where some of the water is filtered out of the solution. The rapid increase of osmotic pressure limits the concentration level in the final product and easily membrane damage requires replacement ⁵.

New non-thermal technologies have been investigated in recent decades for fruit juice concentration, to retain original quality properties ⁶. Freezing concentration ensures high quality of concentrated juices by retaining easily volatile components, but with the highest cost ⁷. By conducting organoleptic testing, Orellana-Palma et al. showed that freezing concentration preserved the original flavor ⁸.

Among the different methods for cryoconcentration, the simplest method is “freezing-thawing (FT)”. The sample is completely frozen, as a single ice crystal and then partially thawed, slowly at room temperature by gravity ⁹. Basically, the freeze-thaw concentration method is block cryoconcentration, and it takes place in three basic stages: freezing, partial melting and separation of ice crystals from the concentrated solution. Both the construction and operation of the equipment make this method simpler than suspension technology.

The suspension crystallization method is based on the formation and growth of ice crystals around crystallization nuclei in a cooled solution, which has the advantage of a large solid-liquid interphase and high energy transfer efficiency ¹⁰. Therefore, the equipment for suspension crystallization contains a device for the nuclei formation, for the crystals growth and for solid-liquid separation from the suspension. Complexity of operations and equipment and high cost, limits application in the food industry ¹¹.

Cryoconcentration has mainly focused on single-stage systems because of its simple procedures for obtaining a concentrated solute. However, the efficiency of separating the concentrated solute from the ice solid phase is low. Therefore, assisted techniques were applied to improve this deficiency in the process ¹². Different technique for freezing and for ice separation has been used to improve separation efficiency and to reduce solute entrapment in the ice. Recently, other techniques have been proposed that can improve the efficiency of cryoconcentration with as little residual dissolved substances in the ice as possible¹³. Vacuum assisted technique has been proposed for cryoconcentration of red wine ¹⁴, orange¹⁵ and blueberry juice¹⁶. Centrifugation, as the most promising methods has been able to slightly increase the efficiency ratio, but it has not exceeded 60% ¹⁷. Freez

⁵ Pangarkar B.L., Sane M.G., Guddad M., Reverse Osmosis and Membrane Distillation for Desalination of Groundwater: A Review, ISRN Materials Science, 2011, pp. 523124

⁶ Petzold G. et al., Physicochemical Properties of Cryoconcentrated Orange Juice Chemical Engineering transactions, vol. 75, 2019, 37-42

⁷ Deshpande S.S., Bolin H.R., Salunkhe D.K., 1982. Freeze concentration of fruit juices. Food Technol. 36, 5, 1982, pp. 68–82

⁸ Orellana-Palma P. et al., Influence of Cryoconcentration on Quality Attributes of Apple Juice (*Malus Domestica* cv. Red Fuji), Applied Sciences, 2020, 10, p. 959

⁹ Miyawaki O., Water and Freezing in Food, Food Science and Technology Research, 24 ,1, 2018, pp. 1-21

¹⁰ Yin, Y. Et al., Progressive freezing and suspension crystallization methods for tetrahydrofuran recovery from Grignard reagent wastewater. J. Clean. Prod., 144, 2017, pp. 180–186

¹¹ Aider m.; halleux d. Cryoconcentration technology in the bio-food industry: principles and applications. Lwt - food science and technology, v. 42, n. 3, 2009, pp. 679-685

¹² Aider, M.; de Halleux, D. Passive and microwave-assisted thawing in maple sap cryoconcentration technology. J. Food Eng. 2008, 85, 65–72.

¹³ Ibid⁸

¹⁴ Orellana-Palma P. Et al., Impact of block cryoconcentration on polyphenol retention in blueberry juice. Food Biosci., 20, 2017, pp. 149–158

¹⁵ Petzold G. Et al., Process parameters of vacuum-assisted freeze concentration, Chemical Engineering Transactions, 57, 2017, 1789-1794

¹⁶ Meneses L. Et al, Multi-stage block freeze-concentration of green tea (*Camellia sinensis*) extract, Journal of Food Engineering, Volume 293, 2021, pp. 110381

¹⁷ Ibid¹³

concentration has been studied on numerous liquid food (tea¹⁸, coffee¹⁹, wine²⁰, mustin²¹), and numerous fruit juices (strawberry²², pineapple²³, apple²⁴, blueberry²⁵).

2. MATERIALS AND METHODS

Apple juice purchased from the local supermarket was used as a starting material. Freezing conditions, temperature and duration of freezing were as proposed by Petzold et al.²⁶. Apple juice (250 ml) was placed in plastic bottles and subjected to freezing in a static freezer at -20 °C, for 12 hours. The samples were unfrozen at room temperature, by gravitation forces. Concentrated juice was collected in a half of initial volume (125 ml). A second concentration by freezing was done with both concentrated and diluted juice, and the thawing and collection procedure was repeated to obtain the final sample.

The solid concentration was analyzed at ambient temperature with a digital refractometer (Atago digital refractometer, RX-5000, Atago U.S.A.). The total acidity was assessed by titration with sodium hydroxide (0.1 N) and expressed in grams of citric acid per liter. The pH was measured using a pH meter (Milwaukee model MW 150, Milwaukee Instruments, Inc. NC, USA).

3. RESULTS AND DISCUSSION

Table 1 shows the content of dry matter, total titratable acid and pH value in the initial juice and concentrated juices, as well as in juices obtained by concentrating the solid phase of ice after separation and thawing.

Table 1. Content of dry matter, total titratable acids and pH value in the initial, concentrated juices and ice phase

Sample Parameter	Starting sample	First concentrate	Second concentrate	First ice	Second ice
Dry Matter (g/100g)	11,22	16,17	23,33	6,15	10,81
pH	3,34	3,31	3,28	3,32	3,32
Total titrable acids (g/L)	5,55	7,35	11,77	3,01	5,09

Total dry matter of the cryoconcentrated apple juice increased by increasing the cryoconcentration stage. The initial total dry matter content of this juice was 11,22 g/100g and it increased up to 16,17 g/100g and 23,33g/100g at the end of the first and second cryoconcentration stages, respectively. In the ice fraction remaining after each cryoconcentration stage total dry matter was 6,15 and 10,81 g/100g respectively.

¹⁸ Ibid¹⁵

¹⁹ Moreno F.L. et al., Effect of separation and thawing mode on block freeze-concentration of coffee brews. Food Bioprod. Process., 91, 2013, pp. 396–402

²⁰ Petzold, G. Et al., Vacuum-assisted block freeze concentration applied to wine. Innov. Food Sci. Emerg., 36, 2016, pp. 330–335

²¹ Hernández E. Et al., Freeze concentration of must in a pilot plant falling film cryoconcentrator, Innovative Food Science and Emerging Technologies, 11, 2010, pp. 130–136

²² Adorno, W.T. et al., Enhancement of phenolic compounds content and antioxidant activity of strawberry (Fragaria×ananassa) juice by block freeze concentration technology. Int. J. Food Sci. Technol., 52, 2017, pp. 781–787.

²³ Orellana-Palma, P. Et al., Effects of centrifugal block freeze crystallization on quality properties in pineapple juice. Chem. Eng. Technol., 43, 2020, pp. 355–364

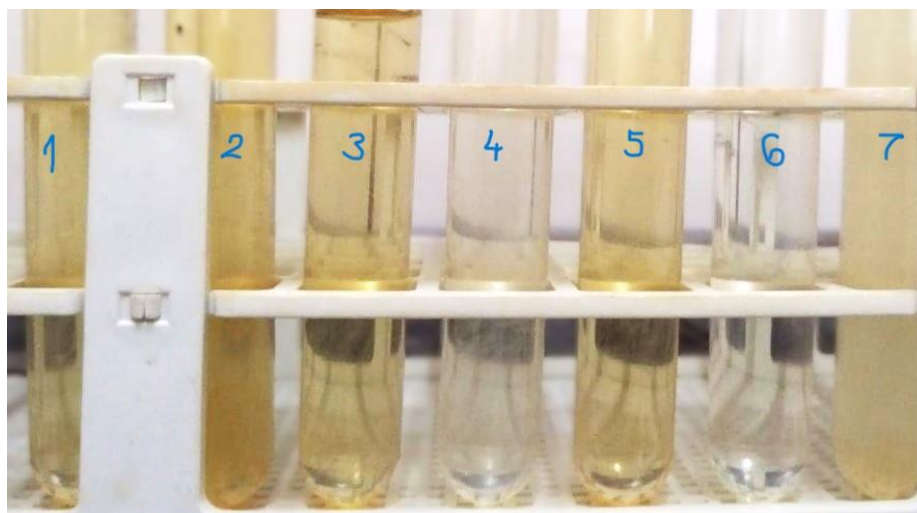
²⁴ Ibid⁸

²⁵ Ibid¹²

²⁶ Ibid⁶

Acidity of the concentrated juices increased from the initial value of 5,5 g/L to 7,35 and 11,77 g/L in first and second concentrate respectively. Slightly drop of the pH value from 3,34 to 3,28 at the end of second concentration, is attributed to concentration of organic acids. Inverse behavior of pH and total titrable acids after cryoconcentration could be explained by the higher content of organic acids in the samples, mainly malic acid. The same behavior was reported by Khajehei et al.²⁷ in the process of concentrating pomegranate juice.

Visual appearance of samples obtained after two concentration stages, both juice and ice fraction are shown in Figure 1. It can be seen that intensity of the colour of the final concentrated apple juice (No. 2) is higher than feed apple juice (No. 5), that is indication of effectiveness of concentration process.



Picture 1. Visual appearance of the samples obtained by freezing concentration of apple juice 1-concentrate of the first ice, 2-second concentrate, 3-first concentrate, 4- Second ice 5- original juice, ice if the first ice concentrate 7- first ice,

The color intensity of the thawed ice fractions obtained after the first (No. 7) and second (No. 4) freezing indicates a lower concentration of color and other soluble ingredients.

Concentration Efficiency (CE) was calculated according to the methodology described by Orellana et al.²⁸. The concentration efficiency represents the relative ratio of the total dry matter in the concentrated solution (C_c) in relation to the dry matter remaining in the ice fraction (C_i) and it was calculated according to Equation (1)

$$CE (\%) = \frac{C_c - C_i}{C_s} \quad (1)$$

where C_c and C_i are total dry matter (g/100g) in the concentrated solution and the ice fraction, respectively. The calculated values are shown in Table 2. The drop in concentration efficiency can be explained by the entrapment of a more concentrated solution in the ice, compared to the first stage of freezing, 16,17 g/100g vs. 23,3 g/100g. It is known that in processes of directional ice growth a phenomenon of polarisation of concentration occurs in the ice solution interface, with accumulation of solutes ahead of the ice that is formed²⁹. There is a tendency of soluble solids to diffuse towards

²⁷Khajehei, F. Et al., Production of pomegranate juice concentrate by complete block cryoconcentration process. J. Food Process Eng. 2015, 38, 488–498

²⁸ Orellana et al., Protection of polyphenols in blueberry juice by vacuum-assisted block freeze concentration. Food Chem. Toxicol. 2017, 109, 1093–1102

²⁹ Miyawaki O., Liu L., Nakamura K., Effective Partition Constant of Solute between Ice and Liquid Phases in Progressive Freeze-Concentration, Journal of Food Science Technology, 1998, 63, 4, pp. 1-3.

Table 2. Concentration efficiency (CE) after apple juice concentration

Sample Parameter	First concentrate	First ice	Second Concentrate	Second ice	Ice concentration	Ice after ice concentration
Dry Matter (g/100g)	16,17	5,79	23,3	10,2	7,59	1,17
Concentration efficiency (%)	64		56		85	

a less concentrated environment. The higher concentration efficiency obtained after the ice fraction concentration (85%) can be explained in the same way.

4. CONCLUSION

Using a simple freezing-thawing method, concentrated apple juice was obtained, in two stages, with a concentration efficiency of 64% and 56% in the first and second stage of concentration, respectively. Attained concentration of total dry matter were 16,17 g/100g and 23,3 g/100g in the first concentrate and in the final apple juice. It was demonstrated that based on on the visual appearance, the concentration method did not change the color of the juice and that it was darker than the initial sample.

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INTEGRATED TECHNICAL SECURITY SYSTEMS IN CRITICAL INFRASTRUCTURE FACILITIES

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Abstract: *In addition to the human factor, which is dominant and key in the security system of critical infrastructure facilities, which by their basic function are institutions with a high security risk, maintaining the required level of security is impossible to achieve without the technical component of the security system. In the modern and changed security context, critical infrastructure facilities face numerous security challenges, risks and threats, which require treatment and an integrated response in synergy between the physical and technical components of the security system. The research is based on the fact that objects of critical infrastructure are specific from the aspect of the security system, because they are institutions, which are subjects of importance for the functioning of the state and society, where there is a constant risk of security incidents. In the paper, by applying the method of content analysis and modeling, it can be concluded that the security problem of objects that are part of critical infrastructure is multi-layered, and its protection must have such a concept, which would be implemented through the integration of various security-technical systems. The degree and method of integration depend on the technical and security characteristics of the system and the type of space and object on which they are applied. Procedural security and technological procedures carried out in the protected area play a significant role in the integration. Taking into account the character of the facilities of these institutions, the positions of individual components of electronic protection should be visible and their presence deters from attempts to realize some form of security threat.*

Keywords: Critical, Risk, Security, Infrastructure, Entities, Technical;

JEL Klasifikacija: Z19

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1. INTRODUCTION

In addition to the human factor, which is dominant and key in the security system of critical infrastructure objects, which by their basic function are objects with a high security risk, maintaining the required level of security is impossible to achieve without the technical component of the security system. In the modern and changed security context, critical infrastructure facilities face numerous security challenges, risks and threats, which require treatment and an integrated response in synergy between the physical and technical components of the security system.⁴ The basic approach in the design of technical protection systems should correspond to the nature of the problem, which entails their multi-layeredness and scalability, i.e. the openness of the designed systems for possible future upgrades both at the level of a single system (eg CCTV) and at the level of an integral technical solution. Designing and installing a technical protection system on a building is only the beginning of accepting the system as an effective means of protecting people and material goods in it. An integral part of the project tasks is the analysis of security problems, which should serve as a basis for getting to know their manifestations, with the aim of finding appropriate technical and security solutions. The security service, regardless of the organizational form by which it is implemented, represents an organizational unit of internal security entities in the narrower sense, and in its work it often encounters challenges and tasks that it cannot implement independently, but relies on the assistance of other authorities. based on what has been presented so far, it can be concluded that the established hypothetical research framework has been confirmed. Objects of critical infrastructure are of special importance for the economic system of every country, so it is of key importance to design technical security systems that are in the function of protecting objects of critical infrastructure. States define critical infrastructure in their own way, having certain similar attitudes, but also differences depending on the general level of development, the level of development and the general condition of the infrastructure, budgetary possibilities, etc. Also, there are different approaches to risk assessment, protection methods and management practices in general. The consequences of different observations of security threats and risks, differences in geographical, historical, and socio-political factors lead to different definitions of the concept of critical infrastructure.⁵ With the rise of technology, the security of the critical infrastructure is growing, but there is a misuse of technology and attacks on sectors. Such dangers lead states to consider their national security strategies. The state needs to concentrate, not only on defending against imminent dangerous or criminal attacks but to focus on the preventive security measures necessary to protect critical infrastructure. Critical infrastructure security is a key issue of modern national security, as critical infrastructure is the basis for community survival. Passing the Law on Critical Infrastructure brings together a wide range of sectors that include critical infrastructure and provide guidelines for its protection. There is no functioning and progress of the state without the possession of the necessary infrastructure and the necessary effective protection of its critical infrastructure.

⁴ Nikač, Ž., Radovanović, R. i Zorić, V., „Privatna bezbednost u Srbiji – pravni osnovi i edukacija pripadnika“, Teme: časopis za društvene nauke, God. 13, br. 1/2, 2018, str. 203.

⁵ Trbojević, M., Zaštita kritičnih infrastrukture - iskustva tranzicionih zemalja, Akademija za nacionalnu bezbednost, Beograd, Politička revija, Vol. 56. br. 2, 2018, p. 99.

2. THREATS TO CRITICAL INFRASTRUCTURE AND VULNERABILITY

Sources of threat to critical infrastructure facilities can be classified in several ways. According to Laporte, it is possible to classify them into two categories, considering their origin:⁶ natural disasters, 2) errors within the infrastructure system, which can be further divided, according to the origin of the cause, into those caused by : – human factor–poor planning of activities within the sector, recklessness of operators, inadequate cooperation or coordination of activities and – due to technical-technological reasons–failure of machines, defective drivers or errors in software used within some infrastructure sector. Attacks on the critical infrastructure system are divided into physical (direct terrorist attacks and sabotage) and virtual (cyber attacks). Also, possible war conflicts could be counted as a threat within this category. Threats to critical infrastructure are a constant scientific challenge and inspiration for researchers around the world. According to the directness of the impact on security, sources of danger are divided into: indirect and direct; when it comes to activity on: latent and active; with regard to constancy, they can be: permanent and occasional; depending on the time of origin, we can classify them as: past, present or future. Each of these groups of threat sources represents a complex based on a certain classification criterion. One of the biggest challenges of the future is global warming, which raises a number of issues such as environmental protection, food, water, energy, health, agriculture, and all of this affects security. First of all, we want to emphasize the lack of drinking water and food, which is in direct contact with the problem of globalization.⁷ Not only are climate changes a security problem in the future, but they represent a major problem in the present because they can cause conflicts over resources, economic damage and risk for coastal cities and key infrastructure, loss of territory and border disputes, migration caused by worsening conditions in the environment.⁸

As previously mentioned, vulnerability analysis is extremely complex, precisely because of the fact that it is present in several forms. The four basic dimensions of vulnerability are: - infrastructural (eng. 'physical vulnerability'), - environmental vulnerability (eng. 'environmental vulnerability'), - economic (eng. 'economic vulnerability') and - social vulnerability (eng. 'social vulnerability'). In addition to this division, institutional and human vulnerability also appear in the literature, but they can also be seen as part of the basic forms of vulnerability. Vulnerability is defined as the degree of loss of an element at risk, which is a consequence of a given hazard of a certain level of strength. It is necessary to distinguish between the vulnerability of the entire infrastructure system and the vulnerability of each of its components (service lines, structural and control system). Conventional vulnerability assessment often focuses exclusively on system vulnerabilities (damaging system structures), but functional vulnerability is almost as important. Functional vulnerability is often greater than structural vulnerability, meaning that functional impairment precedes structural impairment.⁹

3. INTEGRATED SYSTEMS OF PROTECTION OF OBJECTS OF CRITICAL INFRASTRUCTURE

Objects of critical infrastructure represent objects of vital importance for every country, so protecting their security is of utmost importance. It primarily refers to telecommunications facilities, facilities for the production and transmission of electricity, storage and transport of oil, gas and other derivatives, water supply, traffic, facilities of vital state institutions and the like. The protection of

⁶ Papa, M., Sheno, S., Critical Infrastructure Protection II – Emergent Commission of the European Communities, Critical infrastructure protection in the fight against terrorism, Brussels, 2008, pg. 117

⁷ Mićović, M., Cvetković, D., Ugrožavanje infrastrukturnog sistema prirodnim katastrofama usled klimatskih promena. *Ecologica*, No. 78, 2015, str. 333–337.

⁸ Cvetković, V., Vučić, S. i Gačić, J., Klimatske promene i nacionalna odbrana, *Vojno delo*, Vol. 5, 2015, pp. 181.

⁹ Brown, G., Carlyle, M., Salmer, J. i Wood, K., Analyzing the Vulnerability of Critical Infrastructure to Attack and Planning Defenses. *INFORMS Tutorials in Operations Research*, Hanover: Institute for Operations Research and the Management Sciences, 2005, pp. 123.

critical infrastructure facilities is a complex system of security equipment, people and procedures that must be followed in order to ensure that security is at the appropriate level.

The first line of security for critical infrastructure facilities is perimeter protection, and is protected by a combination of burglary protection and video surveillance systems with intelligent video analytics. With IR "beam" detectors, or sensor optical cables, we divide the entire perimeter into a certain number of sectors, behind which fixed cameras are placed for sectoral monitoring of the perimeter. Their work is monitored by a moving camera, which, in the event of a violation of the object's security, monitors the further behavior of a potential attacker. Video analytics plays an important role in this case, in order to reduce the number of false alarms.

By monitoring the movement of people and production processes at critical infrastructure facilities, we control compliance with procedures, while in the event of a fire or some other critical situation, we use the video surveillance system to verify alarms received from other systems, and to evacuate people as efficiently as possible. Large-scale evacuations take time and the situation can quickly become dangerous if panic sets in. Clear notifications help keep coordinated evacuations fully under control. By integrating the fire protection system, video surveillance, access control and evacuation sound system, we improve the efficiency of the operators employed in the control and operation center, and reduce the time required for the evacuation of people from the facility, as well as the response of the fire services.

4. CONCLUSION

The system of technical protection of objects that are part of critical infrastructure is a rounded system of various measures, actions and procedures that keep the system at an optimal level, with the aim of preventing security risks for the institution, employees and residents.

From the aspect of technical means of fire protection in critical infrastructure facilities, it should be emphasized that after determining and identifying the possible causes and sources of fire in the facility, it is necessary to consider what measures should be taken in order to achieve: that a fire does not occur, if it does occur, that it is for a certain time and limited in space, in certain particularly important parts of the object extinguished by an automatic system before it expands. These three requirements are achieved by applying appropriate fire prevention measures (the first two) and designing fire protection systems (the third). Fire prevention measures are defined by the main fire protection project, and are implemented in other main projects. Fire protection systems, the selection of means and techniques are carried out in the main fire protection project, and the technical solutions themselves are implemented through projects of special systems. These solutions are included in the main fire protection project. It can be seen from the above that fire protection design is an interactive process. The fire protection project assesses hazards, proposes solutions, they are implemented through other technical projects, and finally they are entered into the fire protection project. Preventive measures are very numerous and can be reduced to three: technological prevention measures, construction prevention measures and prevention measures for electrical and mechanical installations.

Bearing in mind the above, it can be concluded that optimal and integral technical protection of critical infrastructure facilities should include the application of the following systems, namely:

1. Video surveillance;
2. Perimeter protection;
3. Burglary protection,
4. Control of the tour of the facility,
5. Anti-sabotage protection,
6. Access control and working time records,
7. Intercom and video intercom systems,
8. Sound system,
9. System of storage and control (records) of the use of keys,

10. Mechanical protection,
11. Radio communication system,
12. Personal alarm systems,
13. The lighting system of the perimeter circle and all areas of interest of the KPZ,
14. Uninterruptible power supply system,
15. Information system and computer network,
16. Fire protection system,
17. Electromagnetic compatibility of the technical protection system i
18. Physical protection.

However, it can be concluded that critical infrastructure includes all facilities and systems, whose inactivity or limited use causes social crises situations or even poses a threat to peace and security. Each country has a definition for critical infrastructure, but they have certain similar attitudes and differences depending on the general level of development, the level of development and the general condition of infrastructure, budgetary possibilities, etc. Critical infrastructure includes elements that are essential for the normal functioning of human society.

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PROCESSING POINT ANALYSIS AS QUALITY TOOL IN AUTOMOTIVE INDUSTRY

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Abstract: *The paper presents characteristics of the management methods and application of the processing point analysis in the chosen productive process. To solve the problem presented in the paper, the authors used the method of the processing point analysis applied in the enterprises adapting the quality management model of the World Class Manufacturing. Quality management in productive processes is essential in the formation of the quality of the final product, particularly in the motor industry.*

Keywords: PPA, Processing Point Analysis, Quality

JEL Classification: L23

1. INTRODUCTION

In the years of technological development and economic transformations, the car has become a necessary part of our lives, no longer a luxury. Nowadays, there is an era of inexpensive and reliable cars, accessible to people with average salaries. Customers continuously evaluate products during their use, eliminating car producers whose final product quality does not meet their expectations in terms of quality, functionality, and price. To maintain customer loyalty, producers strive to ensure maximum satisfaction and security guarantees through continuous development of productive systems using appropriate management tools.

Establishments of the basic model of quality management, World Class Manufacturing (WCM), for the production system in the motor industry were presented. Results concerning the use of Processing Point Analysis (PPA) in the process of improving quality for car assembly were also presented, aiming to ensure repeatability of the chosen process in the automotive industry [1]⁴.

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⁴ D. Szewieczek, M.T. Roszak, D. Helizanowicz, Methodology of the quality management in the productive process, Journal of Achievements in Materials and Manufacturing Engineering, 2008

Management, as the main function of task realization, aims to achieve objectives. The quality of management realization depends on various factors that are difficult to define. Quality management serves as the primary tool not just for achieving organizational goals but also for refining both the productive/creative systems and the management of employees and work positions.

The productive system comprises numerous elements and relationships, including transformations of inputs into outputs. It is intentionally designed and organized, incorporating material, energy, and information systems operated by humans to produce specific products aimed at satisfying customers [2]⁵, [3]⁶.

The purposes of each productive system are:

- increase in quality and modernity of products,
- increase in productivity,
- decrease of own costs of production (loss elimination).

The quality of the product created in the productive process is understood dependently on the form of the product. Nowadays, customers in the automotive industry expect the purchased product to meet requirements associated with all measures of quality such as functionality, reliability, and durability. The factory's strategy must be directed towards fulfilling the needs defined by the customer, while also developing features of products or services that precede or even stimulate new needs of potential customers [4]⁷.

2. PROCESSING POINT ANALYSIS (PPA)

Processing Point Analysis (PPA) is an advanced improvement tool designed to address and rectify conditions within complex systems. It proves particularly effective for identifying and rectifying chronic losses that impede performance and yield. One of its key strengths lies in its adaptability across various domains, making it applicable beyond its primary use.

PPA shines in situations where losses stem from multiple interrelated causes, allowing for a comprehensive approach to problem-solving. However, it's important to consider whether this is a full or part time activity.

Teams engaged in PPA can be smaller sizes, with successful outcomes often achieved with as few as two members. Nevertheless, the process entails a significant increase in detail and complexity, requiring meticulous documentation. Work progress is typically recorded on visual boards, which may necessitate a separate board for each step of the analysis.

A crucial component of successful PPA implementation is the presence of an experienced team leader or facilitator who can maintain discipline throughout each step of the process. Additionally, technical expertise must be readily available to address any intricate issues that may arise during analysis and implementation.

3. APPROACH - 7 STEPS OF PPA

The Processing Point Analysis was realized according to 7 steps presented at the Picture 1 [5]⁸.

To explain each step, we will use a simple example of a pillar drill. The Processing Point is the point of contact between the drill and the material. Defects are caused if the drill does not perform this operation perfectly every time. There are five systems that can influence the performance of the drill (Picture 2):

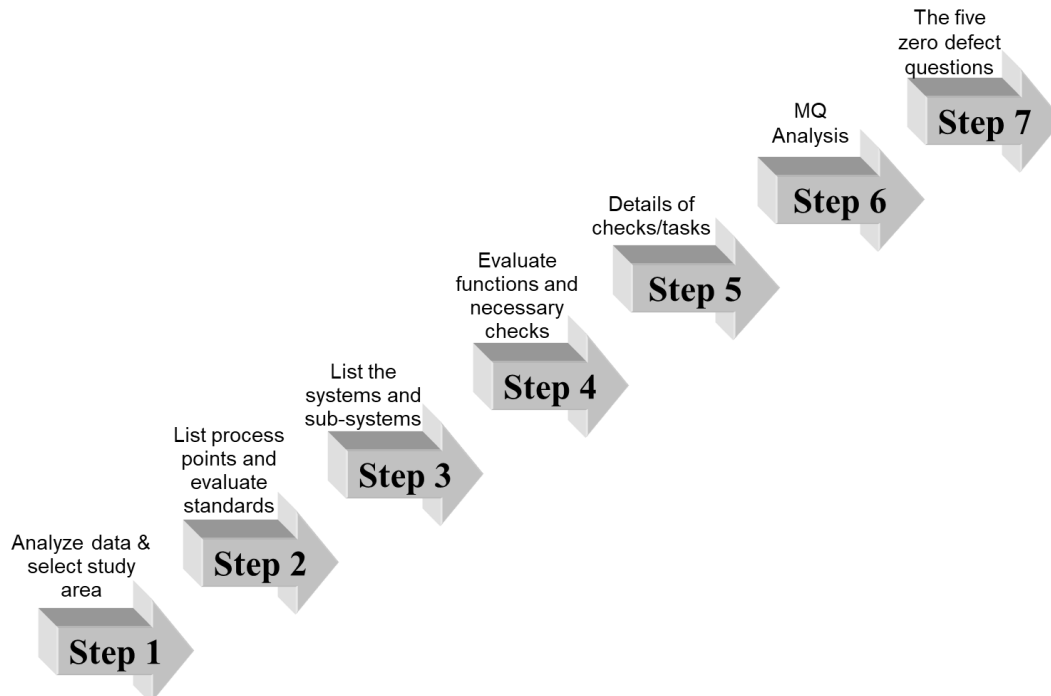
⁵ D. Buchart-Karol, P. Musiaa, The basics of management for engineers, Silesian Technical University Publishing House, Gliwice, 2006.

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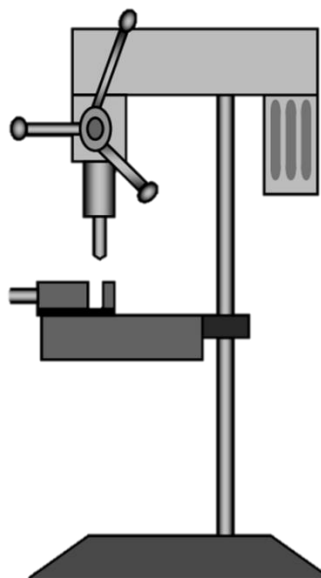
⁷ A. Hamrol, The quality management with examples, PWN, Warsaw, 2005.

⁸ Fiat Auto Serbia, The basic methodologies and instruments for the productive system, Kragujevac, 2014.

1. Lubrication system
2. Driving transmission and power system
3. Electric control system
4. Main equipment
5. Fastening system



Picture 1. Seven steps of PPA



Picture 2. The drill whose systems can affect performance

3.1.Step one

In first step team analyze data and select study area:

- Preparing the description of the phenomenon,
- Preparing the purposes of SMART objectives.

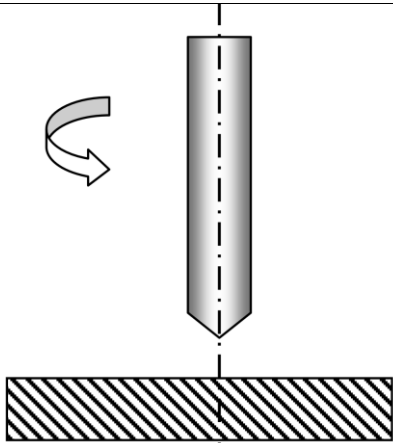
3.2.Step two

Main activity in second step is to create List of process points and evaluate standards:

- Preparing the description of the phenomenon,
- Preparing the description of the rule of this phenomenon,
- Preparing the description of operative standards.

The processing point of the drilling machine is the point where the drill bit contacts the material Table 1.

Table 1. Process points and standards evaluation

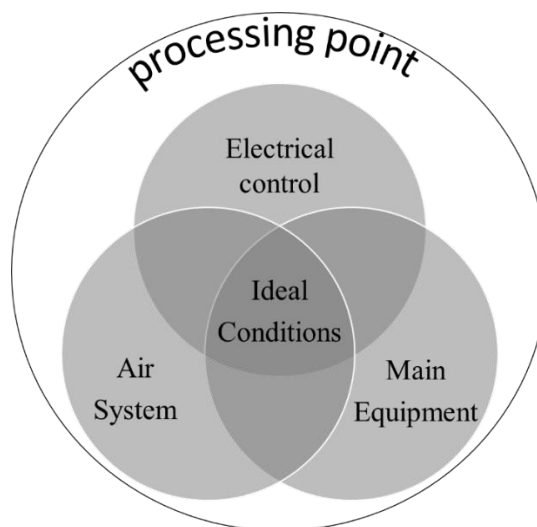
SKETCH	OPERATING PRINCIPLES	OPERATING STANDARDS
	Rotating action of the drill bit to remove the material from the work piece.	1. 12mm HSS drill bit 2. Drill at 90 degrees to work piece. 3. 800 rpm 4. Sharp 118 degree cutting angle. 5. Manual feed rate to be constant

3.3.Step three

List of systems and sub-systems:

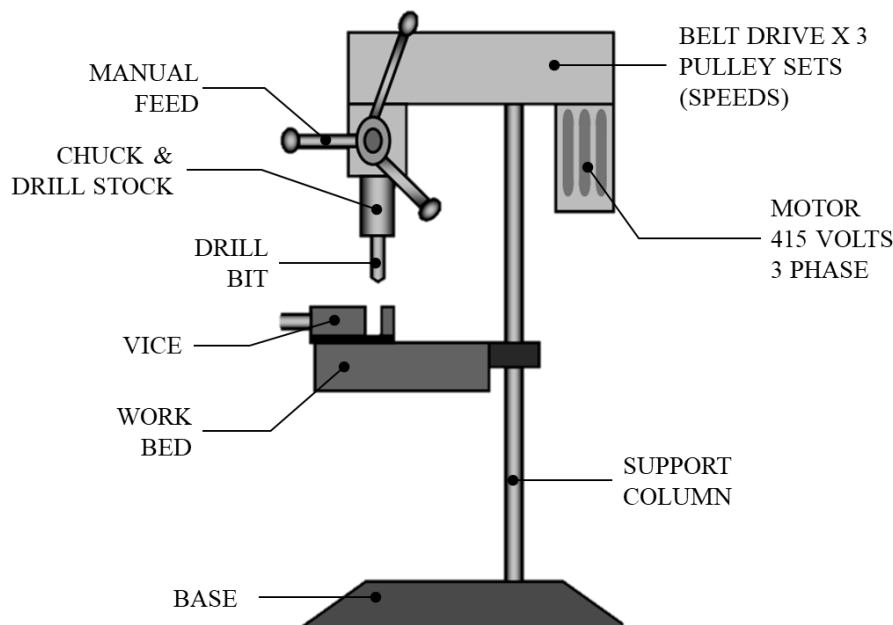
- Identification of sub-systems which participate in production,
- Preparing the list of determined systems and sub-systems.

Many sub systems and processing points belonging to one system can be linked on one line, in order to fulfill one function. Therefore, the presence of deviation at the processing point is determined by the state of each subsystem which contributes to the function of the processing point (Picture 3). When a machine is a cause of producing defectives, it is because one or several sub-systems on a certain line in a certain system does not function properly. Therefore, deviation of the processing point takes place.



Picture 3. Sub-systems of equipment

Once the principle and operating standards of the processing point are established, its contributing systems, such as the main and sub systems, should be clarified by means of proper statements and sketches (Picture 4).

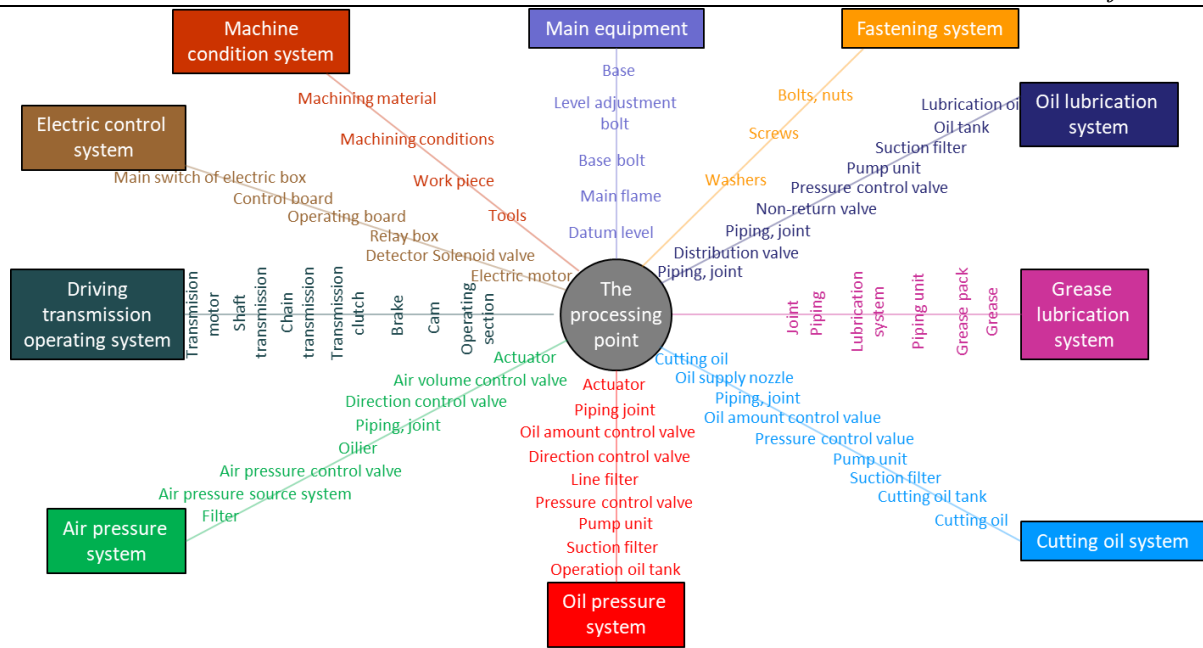


Picture 4. Basic components of drill

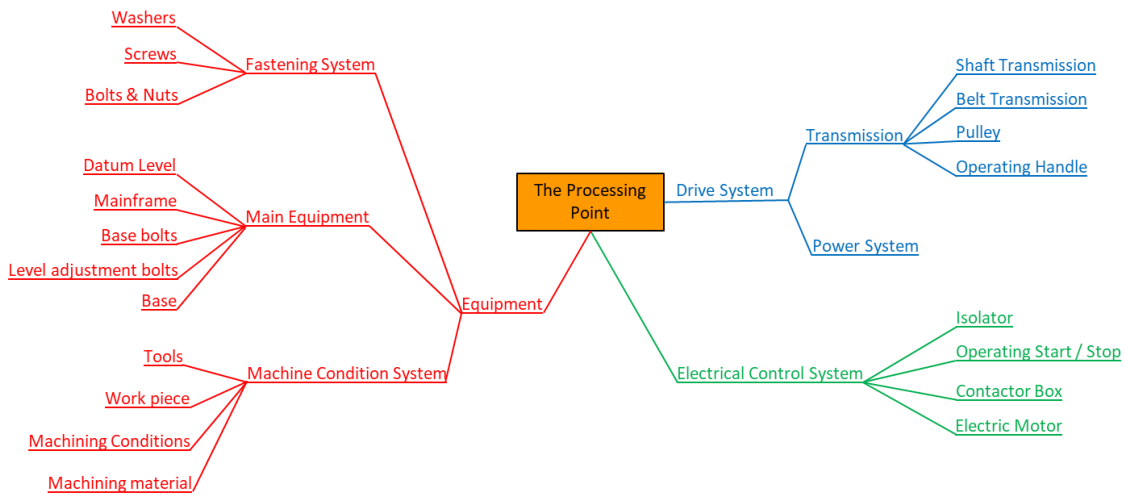
Machine from picture 4 has next types of main and sub systems:

- Lubrication system which keeps rotating parts, sliding sections and contacting sections moving smoothly.
- Hydraulic system which assures the smooth movement of the processing point in linear and rotational direction by hydraulic oil pressure.
- Air pressure system which assures quick and smooth movement of the processing point by air pressure.
- Drive system which changes energy into power.
- Transmission system which increases or decreases the speed.
- Power system which changes power transmitted from the transmission system into the power of operational unit to maintain the continuous movement of the processing point.
- Electric control system which is concerned with the three elements; the formation, positioning and continuity of the processing point, by changing electric energy
- Main equipment system which maintains the balance in processing and the datum level and the required rigidity of the machine.
- Fastening system which fixes many parts to the main equipment and assures accurate operation of each system.

At the end of the fourth step has to identify the sub systems, which contribute to the processing point. Depending on the processing point under investigation, the function may have several or all these systems (presented on picture 5 or picture 6).



Picture 5. System and Sub System Map



Picture 6. System and Sub System Map

3.4.Step four

In step four, the team is analyzing for possible causes of deviation within the system or sub systems and uses the six factors to analyze the system or sub systems (Table 2):

- Name – The system or sub system
- Purpose – What it does within the system
- Function – How does the component provide the purpose
- Components – List the components within the system or sub system
- Principle – How do the components fit together to perform the function
- Operating standards – Necessary conditions and maintenance

Table 2. Example of the 6 Factors

NAME	Electrical control system Electric motor A. C. 415 v (M120)
PURPOSE	Provide rotational power to the drive spindle
FUNCTION	To convert 415V, 3 phase, 50hz electrical energy into mechanical rotation at 1420rpm
COMPONENTS	1. Motor frame 2. End & driven plate

	3. Bearings 4. Windings 5. Drive shaft 6. Armature
PRINCIPLE OF THE FUNCTION	To convert electrical frequency by changing the armature polarity
OPERATING STANDARDS	The motor shaft rotates clockwise at 1420rpm Maintenance - Check motor speed under load

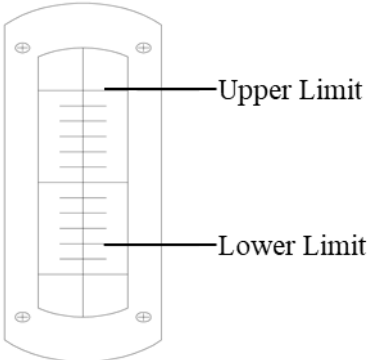
3.5.Step five

Fifth step presents details of verifications/tasks:

- The analysis of the phenomenon,
- Determination of the methods of verifications and criteria of evaluation,
- Description of the found verification of the phenomenon,
- Description of reparative tasks when abnormalities were found,
- The analysis “know-why” is performed when the response for the criterion to check is NO and the solution is not obvious,
- Determination of consequence for not done reparative activities.

In the fifth step we are using Check Method Sheet (Table 3).

Table 3. Check method sheet - example

SECTION	Drawing or illustration 		
Oil Tank			
CHECKING ITEMS			
Check the level on the oil level gauge.			
CHECKING METHODS & EVALUATION CRITERIA	FINDINGS	IMPROVEMENT ACTION IF FINDINGS INCORRECT	CONSEQUENCES IF IMPROVEMENT NOT TAKEN
Clean oil level gauge & check the oil level.	Gauge broken	Change the oil level gauge	Oil leakage will occur from the gauge, this will result in lowering of the oil level. Increase oil usage through wastage which results in cost. Dirty oil gauge makes it difficult to check level. Allow entry of dust/water into oil tank causing contamination.
Check if the upper & lower level limits are indicated on the gauge.	No limits visible	Mark on the gauge the Upper & Lower oil level limits.	Unable to determine level in reservoir. Could result in running below minimum level causing damage / wear to the machine. Can result in overfilling creating mess affecting machine performance and creating a hazard.

If the answer to the criteria for checking is NO and the solution is not obvious, carry out a know-why analysis as in the example below (based on example from table 3):

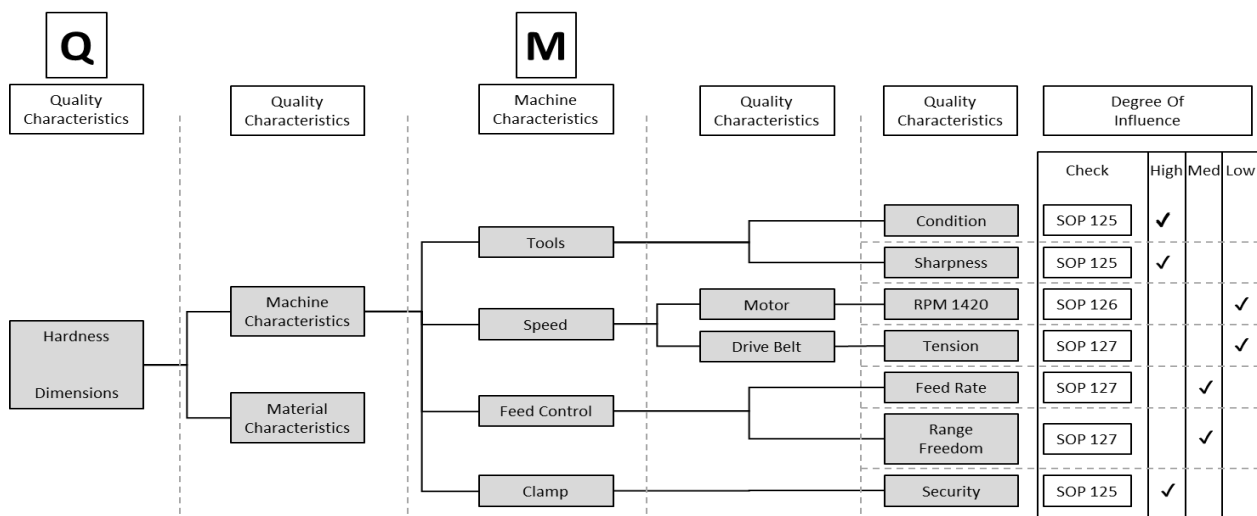
Table 4. Know-why analysis

Improvement directions in the case of “NO”
- Change the oil level gauge - Draw the upper and lower limit lines of the oil level gauge - Supply lubrication oil up to the upper limit line
Know-why (Why is this improvement required?)
- Breakage of oil level gauge → Dust will be mixed in lubrication oil - Dirty oil level gauge, upper and lower limit lines hidden under dirt - Impossible to read the gauge - Overflow takes place at the time of oil supply - Waste of oil - Make the machine and the floor dirty - Insufficient oil quantity - Induction of air - Abnormal wear of the pump - Lower oil pressure - Oil film on the area requiring lubrication is reduced - Unstable transfer of the processing point - Quality defect - Lowered speed - Stoppages by breakdown due to accelerated wear

3.6.Step six

To provide homogeneity, team has to elaborate on QM matrix (picture 7) for verifying critical compounds by following these conditions [6]⁹ (Table 5):

- Parameter – What is to be checked
- Standard value – measurement & tolerance
- Measurement tool – How measured
- Frequency – How often, when
- Responsibility – Who carries out the task



Picture 7. Process diagram for QM matrix

⁹ M. Djordjevic, M. Djordjevic, M. Stanojevic, QX and QM matrix as part of quality maintenance methodology, XI International conference Quality system condition for successful business and competitiveness, Kopaonik 2023.

Table 5. QM Matrix

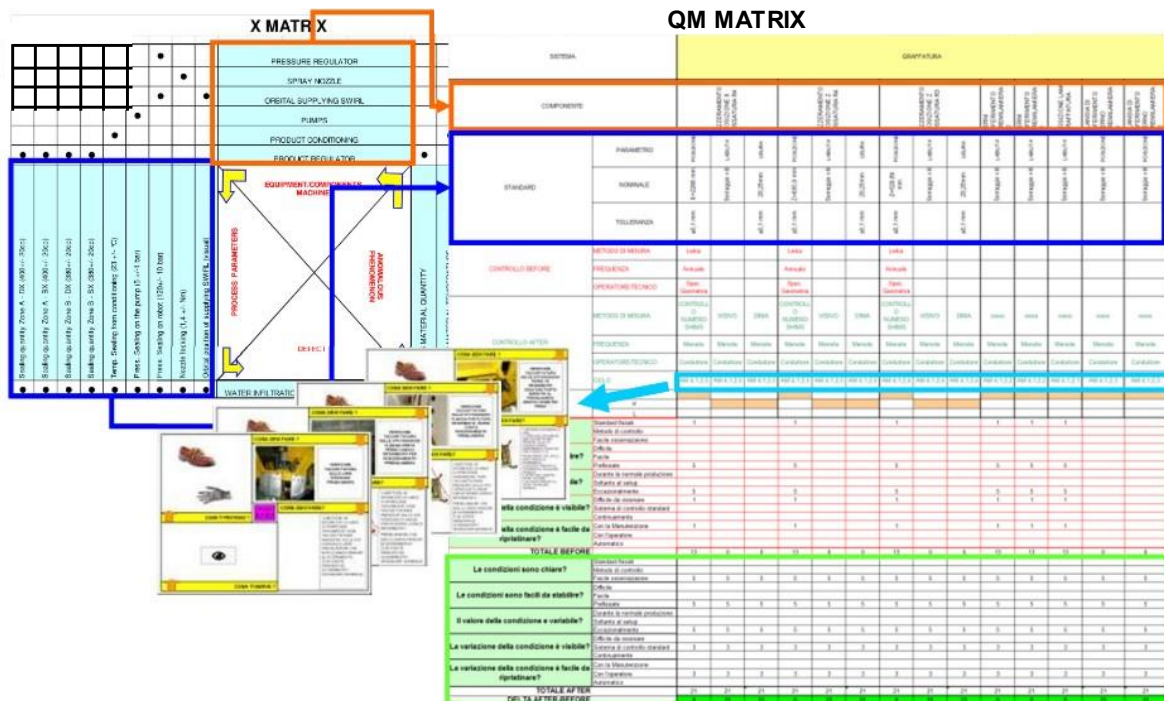
Parameter	Tool Condition	Tool Sharpness	Motor RPM	Belt Tension	Feed Rate	Range Freedom	Security
Standard Value	118 degrees	SOP 125	1420	10 mm deflection	50mm/min	200/0	Zero movement
Measurement Tool	Drill gauge	Audible	Tachometer	Steel rule	Slide scale	Visual inspection	Visual inspection
Frequency	10 pieces	Constant	3 monthly	Daily	Constant	Daily	Constant
Operator/Technician	Operator	Operator	Technician	Operator	Operator	Operator	Operator
Standard	SOP 125	SOP 125	SOP 126	SOP 127	SOP 127	SOP 127	SOP 125
Supervisor	Daily check	Checklist	Checksheet	Checksheet	Training matrix	Checksheet	Daily

Based on the relationships between the quality defect and the process parameters, which QX Matrix highlights, the QM Matrix is used to set up a maintenance schedule that guarantees the maintenance of critical parameters. (Picture 8)

3.7.Step 7

The team asks five questions for no defects. We need to check that the technique achieved the goals set in Step 1. If not go through the process again applying the 5 questions:

1. Are the conditions to be set clear?
2. Are the conditions easy to set?
3. Does the value of a condition or item vary?
4. Is the variation visible?
5. Is the variation easy to restore?



Picture 9. Connection between QX and QM matrix

Table 6. Five question for zero defects

5 QUESTION FOR 0 DEFECT		Before	After
1) Are the condition to be set clear ?	1.1 Fixed and agreed		
	1.2 A method to check them exists		
	1.3 The conditions are easy to read and see	5	
2) Are the condition easy to set ?	2.1 Difficult		
	2.2 Easy		
	2.3 Preset	5	
3) Does the values of item vary?	3.1 During normal production		
	3.2 Only at set-up / start	3	
	3.3 Exceptionally		
4) Is the variation visible?	4.1 Difficult to see it or check it		
	4.2 Standard method to check it		
	4.3 It is continuously visible / checking	5	
5) Is the variation easy to restore?	5.1 By maintenance		
	5.2 By operator	3	
	5.3 It is automatically reset		
TOTAL		21	-
DELTA		4	-

For all objectives maximum score is 25 (first line answer is 1 point, second line answer is 3 points, and third line answer is 5 points). For each delta, a team has to prepare countermeasures to transform score from 1 to 5 for all questions.

4. CONCLUSION

Car manufacturers prioritize continuous improvement in all actions that affect the quality of their products. Achieving effective perfection in products and processes requires the application of appropriate methods and quality management techniques [7]¹⁰.

Methods represent complex approaches to problem-solving, while instruments and techniques are practical procedures grounded in experience, aimed at achieving specific operational goals. These instruments and techniques can be employed individually within management models or as components of broader applied methods. They are applicable across all stages of a product's lifecycle, whereas methods are more focused on specific phases of product creation, tailored accordingly.

Addressing process repeatability issues through Processing Point Analysis (PPA) requires accurate and specific identification of the processing field and its analysis. The presence of deviations at processing points is influenced by the condition of each system and subsystem involved in their function. The focus is on identifying defective subsystems during production rather than waiting until the end of the process.

Processing Point Analysis (PPA) serves as a valuable tool for obtaining critical information regarding Statistical Process Control within the production process, including the results of examinations conducted at parts suppliers for car manufacturers. This facilitates the implementation of appropriate corrective actions. The primary application of PPA should focus on analyzing processing points during the production or assembly of products.

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26th national & 12th international conference QUALITY SYSTEM CONDITION FOR SUCCEFULL BUSINESS AND COMPETITIVENESS

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QUALITY OF LIFE AND EDUCATION WITHIN THE CONCEPT OF A SMART CITY

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Doc. Ksenija Orlandić Osmajić ²

Doc. dr Ivan Bošnjak ³

Abstract: Urban quality is a multidimensional concept that requires the description of several life domains and their mutual interaction. Quality of life can be measured by using objective and subjective indicators. One of the criteria, which is highly important, is education. Quality of life in cities can also be observed within the quality of service that is provided to their users. System of smart cities and smart mobility is a solution for many contemporary challenges. There is a growing need to use AI in problem functioning patterns which requires identifying the cause and finding ways of how to avoid or mitigate negative consequences. Traditional universities in the Republic of Serbia are very limited in solving the complex contemporary problems that require identifying the cause and finding the way how to avoid or mitigate negative consequences. Based on a review of the literature on the quality of life in cities, subjective indicators with the quality of life were identified and quantified using the empirical results of field research, with a special emphasis on education. We identify cause and effect relationships by using the methodology of quantitative comparative analysis of interviews and secondary data. Special contribution of this paper is the observation of complex correlations and pointing out the need for a new methodology at the university through the inclusion of a smart city that can realize many benefits for future generations. The crucial part is the involvement of interested parties in projects.

Keywords: Urban Quality of Life 1, Smart City 2, Education 3, University 4, AI 5

JEL Classification: Z32, L26, Q13

1. INTRODUCTION

“The quality of life is hard to quantify“, says Daniel Chodorkoff. “But the goal of development must be directed towards ensuring people’s safety that their basic needs like adequate food and shelter will be fulfilled, as well as to which non-material areas are often reflected in sensibility.

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Well-being undoubtedly requires a certain degree of economic security, but it rests more on a feeling of social-cultural security”.⁴ This paper studies the quality of life (QOL) in an urban environment. The term surrounding is used in a broader sense that includes physical, social and economic environment. A framework is proposed which assumes that QOL contains life conditions, and satisfaction with such living conditions represents QOL. This kind of objective condition refers to the objective quality of life and satisfaction refers to the subjective quality of life. It was determined that the quality of life dimension is multi-dimensional. It was determined that objective and subjective conditions present a significant dimension of the QOL. However, it was determined that the correlation between objective and subjective life quality is not high. At the same time, it was determined that satisfaction with traffic conditions is the lowest among all variables of satisfaction.⁵

This study uses a descriptive analytical approach to identify general concept of urban quality of life and sustainable development. Besides that, contemporary theories and approaches of urban planning are being analyzed in the context of the smart city concept and the inclusion of universities, which have been applied in many international case studies with the aim of improving the quality of life.⁶ Universities play a vital role in the creation and exchange of knowledge that stimulates innovation and nurtures basic skills that contribute to smarter cities and regions.⁷ By integrating global knowledge into the local context, universities positively influence the development of smart cities.⁸ The concept of a smart city appeared for the first time in 1990s as an alternative to traditional ways of planning, using new technologies for solving urban challenges in a more urbanized world.⁹ A case study approach was adopted for this research. Deduction and induction methods were used. Potential factors of success for the collaboration between universities and governments implementing a smart city project are derived from the literature. The result and the contribution of the work is, among other things, a proposal for an application for universities within the smart city system.

2. SMART CITY, URBAN QUALITY OF LIFE AND SUSTAINABLE DEVELOPMENT

Social inequality is growing in parallel with urban issues, economic collapses are recurring, violence is increasing, planetary riots, health cataclysms, global psychological problems, natural disasters and climate change consequences. Universities have to face the challenge of existence relevant to their communities, national states and the world.¹⁰ The smart city is precisely one of the solutions for the ever-accelerating spatial transformation, encouraging the development of collaborative knowledge in various forms of action.¹¹ The development of an integrated knowledge base, formed by different disciplines and forms of participation, which promotes a sustainable built environment, can become an essential choice for sustainable urban development.

⁴ Chodorkoff, D., Redefiniranje razvoja. Časopis za kritiko znanosti, 33(219), 2005, str.34–43.

⁵ Das, D., Urban Quality of Life: A case Study of Guwahati. Soc Indic Res, 2008, 88: 297.

⁶ Serag El Din, H., et al., Principles of urban quality of life for a neighborhood, HBRC Jurnal, Volume 9, Issue 1, 2013, Pages 86-92.

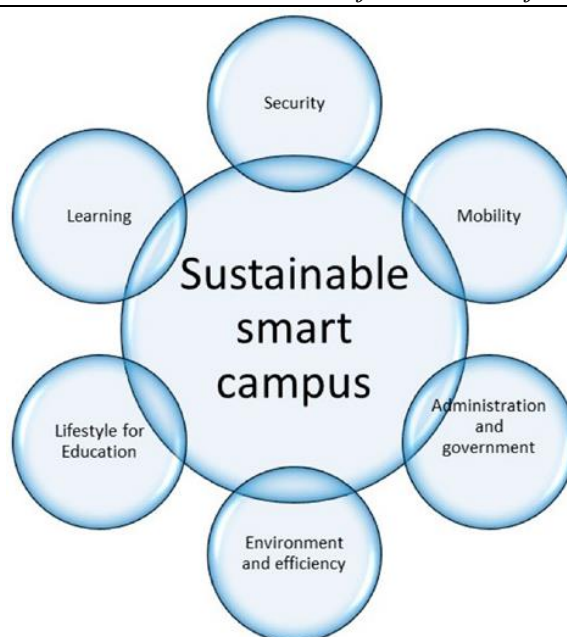
⁷ Ferraris, A., Belyaeva, Z. and Bresciani, S., The role of universities in the Smart City innovation: Multistakeholder integration and engagement perspectives, Journal of Business Research, Volume 119, 2020, Pages 163-171.

⁸ Gómez, G. M., Manyà, V. and Fransen, J., Vital entrepreneurial ecosystems: The case of ICT in Yaba, Nigeria, Cities, Volume 137, 2023, 104289.

⁹ Fernandez-Anez, V., Fernández-Güell, J. M. and Giffinger, R., Smart City implementation and discourses: An integrated conceptual model. The case of Vienna, Cities, Volume 78, 2018, Pages 4-16.

¹⁰ McGregor, S. L. T. and Volckmann, R., Synopsis of Integral Leadership Review's Series on Transdisciplinarity in Higher Education, Integral Leadership Review, 2011, <http://integralleadershipreview.com/2630-transdisciplinarity-in-higher-educationpart-7/>.

¹¹ Stojanović, K., Simeunović, M. and Cvitković, I., Urban Quality of Life and Sociological Benefits of Sustainable Mobility, Institute of Management & Knowledge, SCIENCE International Journal Vol. 2, Issue 4, 2023, 191-196.



Picture 1. Pillars of a sustainable smart campus

Source: Villegas-Ch, W., Palacios-Pacheco, X., Luján-Mora, S., *Application of a Smart City Model to a Traditional University Campus with a Big Data Architecture: A Sustainable Smart Campus. Sustainability*, 2019, 11, 2857. <https://doi.org/10.3390/su11102857>

On the other hand, sustainable development can influence positively or negatively to the quality of life of an individual, because some issues of sustainable development are acceptable and others are unacceptable for an individual member of society. For instance, to achieve a sustainable transport system, drivers may need to drive less; for some people driving a car is more attractive than other modes of transport, due to its comfort, independence, flexibility, speed, perceived safety and privacy; the car also provides more status and pleasure than other modes of transportation; it is the means of self-expression and allows one to control a powerful machine. Consequently, it is important to know which elements of different sustainable development have high or low public acceptability. Apart from that, policy creators must pay special attention to possible effects on the most important quality of life indicators when designing and implementing sustainable development.¹²

One of the most important goals, and objectives of architecture and urban planning, is the right to achieve the maximum possible quality of life. Quality of life is widely used in a wide range of contexts, including fields of international development, health, political science, built environment, education, recreation and free time, social belonging. The term urban quality of life is not used to describe some physical characteristics, but to describe all relationships, dynamics and reticular relations that exist between these physical characteristics.

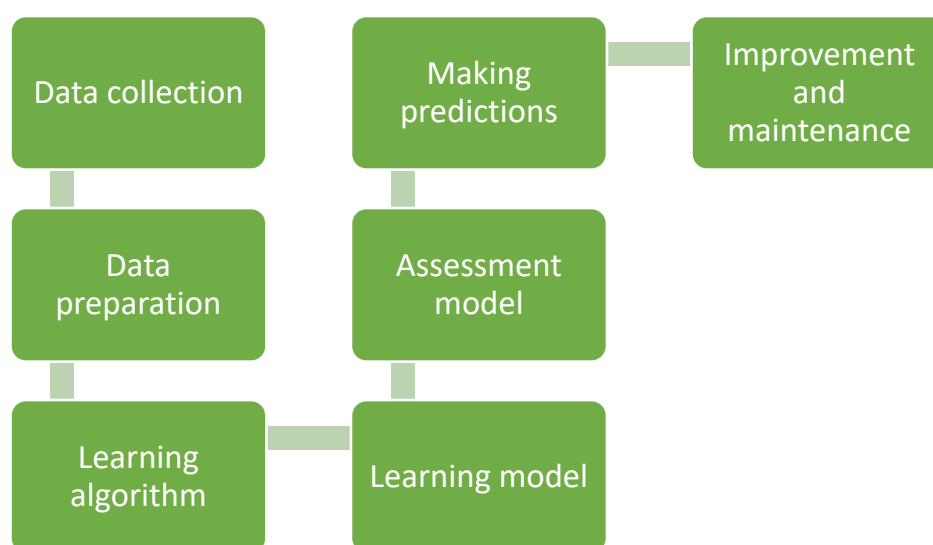
3. URBAN PLANNING IN THE CONTEXT OF THE SMART CITY CONCEPT AND THE INCLUSION OF UNIVERSITIES

In order to promote cooperation and exchange between cities and universities in the region, they gathered nine cities and four universities from Germany, Austria and Switzerland to cooperate on smart cities projects. The project was financed by the European Union and the Swiss Confederation for three years, starting from May 2019 until June 2022. The university of St Gallen collaborated closely with the cities of Bregenz, Berg and St Gallen on establishment of a living laboratory, the development of a smart government strategy and implementation of chatbots in the city

¹² UN-Habitat, *Streets as Public Spaces and Drivers of Urban Prosperity*, Nairobi: United Nations Human Settlements Programme, 2013.

administration. The university of Konstanz, together with the cities of Konstanz and Feldkirch, worked on citizen-oriented services. Specifically, the focus was on the services design and the expansion of the necessary skills and competencies in the city administration. Dornbirn University of Applied Sciences, together with the cities of Dornbirn and Shaflauzen, focused on smart technologies and electronic identity. Zeppelin University collaborated with the cities of Ravensburg, Konstanz and Friedrichshafen on the topics of open data, data mining in public administration and the creation of an urban data space. One of the main reasons for the participation was the establishment of a network that promotes the exchange of knowledge and experience related to the implementation of smart city projects in the cities that are involved.¹³

The way in which a joint project between academic community and practitioners is perceived by the public and politicians can either benefit or hinder cooperation and in a turbulent economic environment, important constituencies such as politicians, managers and prominent citizens may be less inclined to directly or indirectly support research projects.¹⁴ Universities play a vital role in organizing conferences and seminars related to smart city projects in which they are involved with the aim of positive influence on political engagement and shaping citizen's perceptions.¹⁵ Partners who are coming from different countries can bring very different insights into the cooperation. This could improve the resulting research and make it more generally relevant.¹⁶ Existing smart city research supports this by showing that universities, in cooperation with local urban and regional participants, foster innovation and contribute to the development of smart cities and regions.¹⁷ Based on the aforementioned research and the the way the data processing process itself functions¹⁸ and its use in the smart city ecosystem, a model for predicting and improving the educational level using the Internet of intelligent devices is proposed (Internet of Things (short IoT)).



Picture 2. An IoT model of education prediction and improvement

Source: Authors

¹³ Guenduez, A. A., Frischknecht, R., Frowein, S. C. J. and Schedler, K., Government-university collaboration on smart city and smart government projects: What are the success factors?, *Cities*, 2024, Volume 144, 104648.

¹⁴ Rybníček, R. and Königsgruber, R., What makes industry–university collaboration succeed? A systematic review of the literature, *J Bus Econ* 89, 2019, 221–250.

¹⁵ Ferraris, A., Belyaeva, Z. and Bresciani, S., The role of universities in the Smart City innovation: Multistakeholder integration and engagement perspectives, *Journal of Business Research*, Volume 119, 2020, Pages 163–171.

¹⁶ Rybníček, R. and Königsgruber, R., What makes industry–university collaboration succeed? A systematic review of the literature, *J Bus Econ* 89, 2019, 221–250.

¹⁷ Nuzzaci, A. and La Vecchia, L., A Smart University for a Smart City. *International Journal of Digital Literacy and Digital Competence*, 3, 2012, 16–32.

¹⁸ Milošević, D., Ilić, D. and Vulić, M., Machine Learning for Predictive Maintenance in Industry 4.0: Current Trends and Challenges, *XIII International Conference on Industrial Engineering and Environmental Protection*, 2023.

3.1. Application as a result of research

Smart city projects in Serbia can be the beginning of thinking in the direction of implementing technology in all segments of society. In addition to e-administration, healthcare, especially during the pandemic in 2020, etc., we also have applications of e-buses in Serbia, where 10 are currently in operation in Novi Sad and 23 in Belgrade of which 15 are CT (city transport) Belgrade lines EKO1 and EKO2 and 8 private transporter. They contribute to the sustainable transport system of the city, ie. they are environmentally acceptable and have higher efficiency compared to conventional buses.¹⁹ Universities can create an application where each student will have their own login account and from which they will be able to get information about all the questions they have, without going to the faculty. The application would be specially designed to provide practical information and functionality where students would access their own database through their accounts and where they could see basic information about the faculty (lecturer schedule, exams, consultations, etc) but also to schedule consultations with assistants and professors, as well as to monitor classes. This kind of system would be supported in the form of virtual classrooms such as Moodle and Google classroom, where students could follow the lessons without being physically present in the classroom.²⁰ Thus, the frequent travels of students would be reduced, the expenses of the faculty would also be reduced (less heating, less air-conditioned rooms), but students would also be encouraged to adopt a new learning system and their quality of life would improve.

4. CONCLUSION

National policy is of great importance in organizing spatial relations and sustainable development. Some ideas that can be successfully implemented in the urban development of a city in one country, may turn out to be completely useless in some cities in underdeveloped parts of the world. The concept of sustainability is based on the strategy of respecting the urban framework through the long genesis of urban morphology.²¹ The success of sustainable urban and cultural development is viewed in considering the differences that exist in different geographical and social areas. Therefore, the uniform forms that are often created by the dictates of profit are not universally adequate. The identity of the urban community is a highly important component of the future and preservation of the region.²² Urban quality results from a combination of factors related to the city's identity, such as collective memory and contextual influences. The identity of the city and the urban context are directly related to our emotional relationship with the built environment.

The city's future is difficult to develop without cultural heritage, the process of recycling industrial architecture and quality of life. Development of smart cities is one of the main goals of urban sustainability. The integration of universities and smart cities is a promising solution to these challenges, making joint efforts crucial in promoting, implementing and developing innovative and transdisciplinary solutions to multiple problems. The success of the cooperation between the smart city and the university depends on the positive harmonization of all factors, which implies that the failure of even one of them is enough for the cooperation to be considered as unsuccessful, thus emphasizing the fragility of such cooperation. It is possible to enrich the seminar curriculum with the development of smart cities and universities, which can serve as a resource for programs of continuous improvement of education in this area. They can be used to develop new courses, modules and applications for smart city officials, faculties and practitioners from the private sector.²³ The more favourable environment in researching common problems of cooperation would enable an accurate assessment of the strengths and weaknesses of the smart city and university

¹⁹ Mišanović, S., Energetske i ekološke performanse autobusa na električni pogon u sistemu transporta putnika, doktorska disertacija, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, 2021.

²⁰ Koca, I., Digitalne tehnologije koje se koriste u pametnim gradovima, Univerzitet u Novom Pazaru, 2023.

²¹ Hall, S. and Du Gay, P., Questions Of Cultural Identity. Sage Publications Ltd, 1996.

²² Pušić, Lj., Grad, društvo, prostor. Beograd: Zavod za udžbenike, 2015.

²³ Guenduez, A. A., Frischknecht, R., Frowein, S. C. J. and Schedler, K., Government-university collaboration on smart city and smart government projects: What are the success factors?, Cities, 2024, Volume 144, 104648.

cooperation and a thorough research into how success can be facilitated. enumerating by items use the following style.

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26th national & 12th international conference QUALITY SYSTEM CONDITION FOR SUCCEFULL BUSINESS AND COMPETITIVENESS

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THE IMPACT OF INDUSTRY 5.0 ON THE SUPPLY CHAIN: CHALLENGES AND OPPORTUNITIES

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Matija Kovačić, PhD ²

Maja Mutavdžija, PhD ³

Abstract: Industry 5.0 represents the evolution of Industry 4.0. and brings with it an upgrade of the existing technologies contained in Industry 4.0. emphasizing the cooperation between human and automated systems. The technologies and technological innovations contained in Industry 5.0 affect a wide range of systems, and one such system is the supply chain. By implementing technological innovations such as artificial intelligence, blockchain, big data, and the like, stakeholders in the supply chain can have significant advantages in the context of increasing efficiency and effectiveness. However, on the other hand, there are challenges related to data security as well as the availability of financial resources for small and medium-sized enterprises to implement Industry 5.0 technologies. With this in mind, this paper aims to investigate what challenges and opportunities arise in the context of the emergence of Industry 5.0 and how Industry 5.0 technologies generally affect the supply chain.

Keywords: supply chain, industry 5.0, industry 4.0, challenges and opportunities

JEL Classification: L10, M10

1. INTRODUCTION

Industrial operations have long relied heavily on supply chain management to enable the smooth transfer of resources and goods from suppliers to end users. A major advance in supply chain optimization was brought about by the introduction of Industry 4.0, which is defined as a combination of automation and digital technology.⁴ Progress toward Industry 5.0 results in visible revolutionary changes that emphasize connectivity, data-driven decision-making, and the merging of digital and physical systems.⁵

Industry 5.0 is a new era defined by the integration of sophisticated analytics, artificial intelligence, and the Industrial Internet of Things (IIoT) in a conventional industrial environment. With this

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³ Maja Mutavdžija, PhD, Croatia, maja.mutavdzija@gmail.com

⁴ Tjahjono, B., Esplugues, C., Ares, E., & Pelaez, G. (2017). What does industry 4.0 mean to supply chain? Procedia manufacturing, 1175-1182.

⁵ Frederico, G. F. (2021). From supply chain 4.0 to supply chain 5.0: Findings from a systematic literature review and research directions. Logistics, 49.

paradigm shift, supply chains have never before seen opportunities for optimization that will increase their sustainability, resilience, and agility.⁶ Supply chain actors can use artificial intelligence and data analytics to their advantage to quickly adapt to changing consumer demands and market conditions.

Considering the importance of Industry 5.0 and the technologies contained in Industry 5.0 and their applicability in the supply chain, this paper aims to investigate what challenges and opportunities appear in the context of the emergence of Industry 5.0 and how Industry 5.0 technologies generally affect the supply chain.

This work is based on a systematic review of literature indexed in relevant scientific journals by the keywords "Supply chain" and "Industry 5.0". It is divided into a total of 6 chapters. In the first chapter, the context is given, that is, an introduction to the topic and the significance of the topic of the influence of Industry 5.0 on the supply chain, that is, the challenges and opportunities that appear with the emergence of new technologies contained in Industry 5.0. In Chapter Two, an overview of existing positions in the literature, ie existing research, is given. The third chapter describes the methodology used, while the fourth chapter presents the results of the conducted research. The fifth chapter is the discussion chapter while the last sixth chapter is the concluding chapter.

2. OVERVIEW OF EXISTING RESEARCH

2.1.Industrial revolutions

The first industrial revolution (Industry 1.0) marked the beginning of the generation of mechanical energy through water, steam, and fossil fuels, laying the foundations for modern industry.⁷ As the world entered the period between 1871 and 1914, there was a transition to Industry 2.0, which is characterized by a faster transfer of people and innovations thanks to mass production and the development of transport infrastructure. This era brought economic growth and increased productivity, but it also caused unemployment to grow as machines began to replace human labor in factories.⁸ Almost a century later, during the 1970s, with the advent of electronics and computers in production, the Third Industrial Revolution (Industry 3.0) began. This era introduced microprocessors, information technology, and robots, contributing to a high level of automation in manufacturing. It accelerated globalization and led to the outsourcing of production due to access to qualified labor and lower production costs.⁹ Industry 4.0 represents the next step in evolution, focusing on the integration of intelligent machines and systems that transform production processes to increase efficiency. It is characterized by the use of cyber-physical systems, the Internet of Things (IoT), cloud computing, cognitive computing, and artificial intelligence. Industry 4.0 brings resilient technology, and new ways of working and emphasizes the role of people in industrial processes. Industry 4.0 has introduced several technologies that have significantly impacted supply chain management, such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI), and advanced robotics. Industry 5.0 is a term used to describe the next phase of industrial development that is based on the foundations of Industry 4.0. Industry 5.0 could advance this progress and bring a more holistic approach that emphasizes human-machine collaboration, adaptation, and sustainability.¹⁰ Industry 5.0 represents the upcoming wave that aims to improve and intelligentize the machines of the previous generation, focusing on efficiency and intelligence. This concept, considered by research

⁶ Akundi, A., Euresiti, D., Luna, S., Ankobiah, W., Lopes, A., & Edinbarough, I. (2022). State of Industry 5.0—Analysis and identification of current research trends. *Applied System Innovation*, 27.

⁷ Nahavandi, S. (2019). Industry 5.0—A human-centric solution. *Sustainability*, 4371.

⁸ Adel, A. (2022). Future of industry 5.0 in society: human-centric solutions, challenges and prospective research areas. *Journal of Cloud Computing*, 40.

⁹ Zakoldaev, D. A., Shukalov, A. V., & Zharinov, I. O. (2019). From Industry 3.0 to Industry 4.0: Production modernization and creation of innovative digital companies. In *IOP conference series: Materials Science and Engineering*.

¹⁰ Grabowska, S., Saniuk, S., & Gajdzik, B. (2022). Industry 5.0: improving humanization and sustainability of Industry 4.0. *Scientometrics*, 3117-3144

and technology organizations under the auspices of the European Commission in 2020, emphasizes the critical directions of change for the realization of a more sustainable and human-centric industry.¹¹

2.2. Industry 5.0 and the supply chain

The fifth industrial revolution has a great potential for strategically optimizing the supply chain. The system of people and institutions that work together to move goods and services from the raw stage to final consumption is known as a supply chain, and any unprecedented situation that disrupts supply chains and their operation is known as a supply chain disruption. For any company, the supply chain is the heart of its business, and the occurrence of any critical global event can put the supply chain at risk.¹² Compared to the isolated and compartmentalized systems of earlier industrial revolutions, Industry 5.0 is a change. It emphasizes how human talents, material assets, and digital technology work seamlessly together. Although still in its infancy, the idea of Industry 5.0 promises to improve supply chain responsiveness, flexibility, and connectivity.¹³ Industry 5.0 brings a new wave of technological progress that emphasizes the interaction between man and machine and tends towards greater personalization and flexibility in production. In this context, operations planning will change significantly. The focus will shift from traditional mass production to production processes that can quickly adapt and respond to individual customer requirements.

Embracing advanced digital technologies such as artificial intelligence, machine learning and the Internet of Things will be key in this transition. These technologies will enable the integration of human creativity and innovation into the production process, creating unique and customized products. This approach implies changes in the supply chain, which must become significantly more responsible and adaptable.¹⁴

Supply chain planners will be challenged to monitor changing market demands in real time and use data to inform their decisions. The integration of the mentioned digital technologies will enable them to efficiently analyze data, predict trends, and quickly react to changes.¹⁵

In addition to technological innovations, Industry 5.0 will also require stronger cooperation between manufacturers, suppliers and customers. The development of new partnerships based on shared values, especially in the context of sustainability, will become increasingly important. Such synergy between different actors in the supply chain will allow greater agility and the ability to respond to the specific needs and wishes of end users.

Industry 5.0 will not only transform the way products are manufactured and distributed, but will also change the nature of work, requiring new skills and approaches in both management and execution of operations. In addition, intelligent robots and systems will influence supply chains to an unprecedented level, highlighting that Supply Chain 5.0 is a trend that includes three main perspectives: collaborative work between humans and robots (cobots), mass customization and personalization for customers, and a super smart society (Society 5.0).¹⁶

¹¹ Lu, Y., Zheng, H., Chand, S., Xia, W., Liu, Z., Xu, X., & Bao, J. (2022). Outlook on human-centric manufacturing towards Industry 5.0. *Journal of Manufacturing Systems*, 612-627

¹² Agrawal, S., Agrawal, R., Kumar, A., Luthra, S., & Garza-Reyes, J. A. (2023). Can industry 5.0 technologies overcome supply chain disruptions?—a perspective study on pandemics, war, and climate change issues. *Operations Management Research*, 1-16

¹³ Vatin, N. I., John, V., Nangia, R., & Prasanna, Y. L. (2024). Supply Chain Optimization in Industry 5.0: An Experimental Investigation Using AI. *BIO Web of Conferences* (Vol. 86, p. 01093). EDP Sciences.

¹⁴ Minculete, G., Bârsan, G., & Olar, P. (2021). Conceptual approaches of industry 5.0. Correlative elements with supply chain management 5.0. *Revista de Management Comparat International*, 622-635

¹⁵ Badulescu, Y., Hameri, A. P., & Cheikhrouhou, N. (. (2022). Sustainable partner selection for collaborative networked organisations with risk consideration in the context of COVID-19. *Journal of global operations and strategic sourcing*, 97-218

¹⁶ Frederico, G. F. (2021). From supply chain 4.0 to supply chain 5.0: Findings from a systematic literature review and research directions. *Logistics*, 49.

Industry 5.0 will require a greater focus on sustainability and social responsibility in business planning. This will include optimizing production processes to reduce waste, minimize environmental impact and promote social well-being. It will also require a greater emphasis on transparency and ethical practices throughout the supply chain. Moreover, Industry 5.0 will require a greater emphasis on creativity and innovation in supply chain planning. Supply chain planners will need to be able to think outside the box and come up with new ideas and approaches to optimize manufacturing and supply chain processes. This will require a change in mindset from traditional planning methods to more innovative and agile approaches.

3. METHODOLOGY

The research is based on a systematic literature review, i.e. literature references indexed in the WoS and Scopus databases. At the beginning of the research, the keywords "Supply chain" and "Industry 5.0" were defined. References found in books, scientific journals, and lectures at conferences are defined as search criteria. By searching the WoS and Scopus database and combining the obtained results and excluding repetitive literature references, a total of 132 references were included in the research.

The period from 2001 to 2024 was chosen as the period in which the references were published. During the analysis of the obtained results, the scientific journals in which the largest number of scientific and professional articles included in the research were published, the productivity of the authors, i.e. the authors who have the largest number of published works in the area of the influence of Industry 5.0 on the supply chain, and the most significant works, i.e. the works which have the greatest influence on other authors. The total number of citations was selected as a criterion for selecting the most significant papers.

4. RESEARCH RESULTS

Based on the conducted research, it was identified that the average annual growth of scientists' interest in the impact of new technologies on the supply chain is 8.83%. The number of authors who are active in the research, based on the selected sample, is 159 authors, of which there is only one author on 5 scientific papers included in the research. If we talk about collaboration between authors, 54% of all works were created as collaboration between two or more authors.

In terms of citations, the average number of citations per scientific paper is 22.96. The scientific papers included in the research are on average 1.66 years old, while the average number of authors per paper is 3. The authors used a total of 193 keywords for the topic of Industry 5.0 challenges and their impact on the supply chain.

4.1. Analysis of author productivity

Table 1 shows the analysis of the number of completed papers by author. The Table shows that the largest number of authors come from Eastern countries, primarily China and India. However, it should be emphasized that the most productive author is Dmitry Ivanov, who comes from Germany, which can be interpreted through the fact that the beginning of Industry 4.0 was recorded precisely in Germany and that Industry 4.0 flows into the foundations for the study of Industry 5.0.

Table 1: Overview of author productivity

Author	Number of papers	Country
Dmitry Ivanov	5	Germany
Soni Agrawal	3	India
Zhen-Song Chen	2	China
Dindayal Agrawal	2	India
Tazim Ahmed	2	Bangladesh

Source: The table is the work of the author

It should be emphasized that the order of authors in the table who have an equal number of works is the same in terms of importance, i.e. the ranking of authors who have an equal number of works does not determine their importance and contribution.

4.2. Source analysis

Table 2 shows the analysis of sources, i.e. scientific journals in which the author publishes the largest number of papers. As can be seen, Information Systems Frontiers stands out as the scientific journal that published the largest number of papers with a total of 5 published papers, which represents a share of 3.78% of the total number of published papers included in this research, followed by Computers Industrial Engineering with a total of 3 works, which represents a total of 2.27% of the works included in the research. In third place is the International Journal of Production Research with a total of 3 published papers, representing a total of 2.27% of the papers included in the research, while in fourth and fifth place are Cleaner Logistics and Supply Chain and Logistics with a total of 2 published papers each, representing 1,51% of the published works included in the research.

Table 2: Overview of journals with the most published papers

Source	Total number of papers
Information Systems Frontiers	5
Computers Industrial Engineering	3
International Journal of Production Research	2
Cleaner Logistics and Supply Chain	2
Logistics-Basel	2

Source: The table is the work of the author

It should be emphasized that the arrangement of journals in the table does not determine their significance, which means that all journals with the same number of papers are equally significant.

4.3. Analysis of the productivity of countries

Table 3 shows the analysis of the countries' productivity. It should be emphasized that the total number of papers belonging to a particular country includes the total number of scientific papers published by authors from the country. India stands out as the most productive country with a total of 7 published scientific articles, which represents a share of 5.30% of the total number of published works, followed by China with a total of 5 published works, representing 3.78%, in third and fourth place is Germany and the United Kingdom with a total of 4 published works representing 3.03% and Portugal with a total of 3 published works representing a share of 2.27%.

Table 3: Overview of countries' productivity

Country	Total number of papers
India	5
China	3
Germany	2
United Kingdom	2
Portugal	2

Source: The table is the work of the author

It should be emphasized that countries with the same number of papers have the same importance, regardless of their position in the table.

4.4. Analysis of works

Table 4 shows the 5 most important works included in this research as well as their most significant contribution.

Table 4: Overview of papers with the highest number of citations

Authors	Title of the article	Number of citations	Author's contribution	Type of research
(Maddikunta, et al., 2022)	Industry 5.0: A survey on enabling technologies and potential applications.	407	Looking at the possibility of personalizing products and services as well as the possibility of applying new technologies based on artificial intelligence. The paper examines the impact that Industry 5.0 technologies have on the manufacturing sector, healthcare, etc.	Primary research
(Ivanov, 2023)	The industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives.	107	Understanding how Industry 5.0 affects the supply chain and flexibility, i.e., the ability to adapt the supply chain to new technologies. The paper analyzes the principles contained in Industry 5.0 and how the principles imply the operations of stakeholders involved in the supply chain.	Review article
(Ivanov, Dolgui, & Sokolov, 2022)	Cloud supply chain: Integrating Industry 4.0 and digital platforms in the “Supply Chain-as-a-Service”.	87	The article analyzes a supply chain solution based on cloud technology and talks about the creation and management of the supply chain as a service that organizations can request, i.e., receive as a service from other organizations. This kind of approach is a novelty, and, in the future, it could significantly influence new trends in the field of supply chain management.	Review article
(Stephens, 2021)	Supply chain operations reference model version 5.0: a new tool to improve supply chain efficiency and achieve best practice	87	It does not speak directly about Industry 5.0 and its impact on the supply chain but looks at the concept of supply chain management based on the SCOR 5.0 model, which is used to manage efficiency and effectiveness, i.e., return on investment.	Review article
(Adel, 2022)	Future of industry 5.0 in society: human-centric solutions, challenges, and prospective research areas	76	A review of the literature in which the authors consider the possibilities of using the technologies of Industry 5.0 in different areas. Technologies that are considered are technologies such as artificial intelligence, big data, blockchain, and the like.	Review article

Source: The table is the work of the author

As can be seen in Table 4, the most significant works provide an overview of the possibilities of using various technologies contained in Industry 5.0 and their impact on the supply chain, i.e. the possibility of increasing efficiency and effectiveness. It is necessary to emphasize that the most significant works are also the works whose authors are the most productive in this field.

5. DISCUSSION

One of the key benefits of Industry 5.0 for supply chain management is increased efficiency and speed. With the integration of IoT and AI, businesses can gain insight into their supply chains in real time, allowing them to quickly respond to any issues that may arise. This increased visibility and control will also enable organizations to reduce costs by reducing waste, minimizing errors and streamlining processes.¹⁷

Industry 5.0 can influence supply chain management through a number of factors, one of the most significant of which is the collaboration between people and machines.¹⁸ Industry 5.0 envisions a future where humans and machines work together more seamlessly. This can impact supply chains by incorporating human expertise into decision-making processes with AI-driven analytics.¹⁹ This joint approach could lead to better forecasting, risk management and more adaptive responses to disruptions. In addition, Industry 5.0 enables customization and personalization, which means it enables manufacturers to produce customized products on a large scale. This can affect supply chains by requiring more flexible production processes and agile supply networks capable of responding to individual customer demands.²⁰ It also decentralizes production, which can lead to shorter supply chains, reduced transportation costs, and potentially more sustainable operations. It also encourages and emphasizes sustainability which may include the use of artificial intelligence and data analysis to optimize energy consumption, reduce waste and minimize environmental impact.²¹

Implementing Industry 5.0 in supply chains is difficult for small industries. Since they do not have enough financial resources for investment.²² Some of the challenges faced by companies in the implementation of Industry 5.0 in supply chains are the cost of technology, data security, given that the entire concept of Industry 5.0 is based on data and data analysis, lack of employee competencies that will use Industry 5.0 technologies, and the like.²³ Therefore, despite the many benefits of Industry 5.0 for supply chain management, there are also several challenges to overcome. One of the biggest challenges is the need for significant investments in new technology and infrastructure. This can be a significant barrier for SMEs, making it difficult for them to adopt Industry 5.0 and compete with larger organizations. In addition, there is a risk that increased automation could lead to job losses and a decrease in the number of qualified workers in the workforce.²⁴

Despite these challenges, the potential benefits of Industry 5.0 for the supply chain are significant. Companies that are able to successfully apply these technologies can gain a competitive advantage and improve their bottom line.

It is important to note that the full impact of Industry 5.0 on the supply chain will depend on how it is adopted and integrated in different industries. As the concept continues to evolve, businesses will

¹⁷ Min, H. (2010). Artificial intelligence in supply chain management: theory and applications. *International Journal of Logistics: Research and Applications*, 13-39.

¹⁸ Alves, J., Lima, T. M., & Gaspar, P. D. (2023). Is industry 5.0 a human-centred approach? a systematic review. *Processes*.

¹⁹ Modgil, S., Singh, R. K., & Agrawal, S. (2023). Developing human capabilities for supply chains: an industry 5.0 perspective. *Annals of Operations Research*, 1-31.

²⁰ Wang, X., Xue, Y., Zhang, J., Hong, Y., Guo, S., & Zeng, X. (2024). A Sustainable Supply Chain Design for Personalized Customization in Industry 5.0 Era. *IEEE Transactions on Industrial Informatics*.

²¹ Karmaker, C. L., Bari, A. M., Anam, M. Z., Ahmed, T., Ali, S. M., de Jesus Pacheco, D. A., & Moktadir, M. A. (2023). Industry 5.0 challenges for post-pandemic supply chain sustainability in an emerging economy. *International Journal of Production Economics*, 108806.

²² Movahed, A. B., Movahed, A. B., & Nozari, H. (2024). Opportunities and Challenges of Smart Supply Chain in Industry 5.0. *Information Logistics for Organizational Empowerment and Effective Supply Chain Management*, 108-138.

²³ Xu, X., Lu, Y., Vogel-Heuser, B., & Wang, L. (2021). Industry 4.0 and Industry 5.0—Inception, conception and perception. *Journal of manufacturing systems*, 530-535

²⁴ Gagnidze, I. (2023). Industry 4.0 and industry 5.0: can clusters deal with the challenges?(A systemic approach. *Kybernetes*, 2270-2287.

need to assess its potential benefits and challenges and adapt their strategies to keep up with the changing landscape of manufacturing and supply chains.

6. CONCLUSION

Industry 5.0 represents an evolution from Industry 4.0, focusing on collaboration between people and smart systems. This approach emphasizes personalization, sustainability, and efficiency, and tends to optimize resources and improve jobs through the humanization of technology. The impact of Industry 5.0 on supply chains is significant and brings both challenges and opportunities.

Industry 5.0 enables companies to provide highly personalized products and services, responding to the specific needs of customers. This increases customer satisfaction and loyalty and makes supply chains more flexible in responding to changing market demands. A focus on sustainability means optimizing the use of resources and reducing waste, which can lead to more efficient supply chains. Implementing smart technologies can help monitor and manage resource consumption, reducing the environmental footprint.

Technologies such as IoT (Internet of Things), artificial intelligence, and robotics enable better communication and integration between different parts of the supply chain, leading to greater transparency and efficiency. Humanizing technology and focusing on the workforce can improve working conditions, safety, and employee satisfaction, leading to higher productivity.

When it comes to the challenges of Industry 5.0 on the supply chain, it can be concluded that the implementation of advanced technologies requires significant initial investments in software, hardware, and employee training, which can be a challenge for smaller companies. To take advantage of Industry 5.0, the workforce must be trained to work with new technologies. This requires continuous training and skills development programs.

Also, increased connectivity and the use of smart technologies expose supply chains to greater data security risks. It is necessary to invest in advanced protection systems in order to preserve the privacy and integrity of data. The rapid adoption of new technologies can encounter regulatory hurdles, especially with respect to privacy, security, and ethical standards.

Industry 5.0 provides great opportunities for improving supply chains, making them more flexible, sustainable, and efficient. However, companies face challenges that require careful planning, investments, and adaptation in order to make the most of the advantages that Industry 5.0 offers.

The future of supply chains in the Industry 5.0 era is exciting and filled with opportunities for businesses of all sizes. By embracing advanced technologies such as IoT, artificial intelligence, and robotics, organizations can increase efficiency, reduce costs and improve customer satisfaction. However, significant investments and willingness to adapt and change will be needed to fully realize the potential of Industry 5.0 in supply chains.

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CHALLENGES IN THE PROCESS OF DESIGNING HYDRAULIC MACHINES WITH CYCLOIDAL GEARS

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Summary: Cycloidal gear pairs have been widely used in designing various types of hydraulic machines. The paper examines contemporary research aimed at the design of cycloidal gear profiles and analysis of the impact of their geometry on functional characteristics of the gerotor pumps in which they are built in. Depending on the chosen generating coordinate systems, three original approaches for obtaining cycloidal profiles are shown. If the geometric parameters of the cycloidal gears are chosen in an optimal way, they can lead to a reduction of contact stress and to an increase in the degree of utilization of gerotor pumps. Proper operation and installation of gear pairs in gerotor pumps can be ensured through thoroughly conducted kinematic analysis. Dynamic analysis of a gerotor pump can be used to monitor the impact of the range angle on output parameters: pressure, flow rate and fluid volume. The aim of the study is to help researchers to better understand the design of hydraulic machines with cycloidal gears.

Keywords: gerotor pumps, cycloidal gears, kinematic analysis, pumps design

JEL Classification: L00

1. INTRODUCTION

Challenges in the process of designing hydraulic machines, encountered by engineers and researchers, prompted the application of cycloid (trochoid) gears as a solution of most problems of gear pairs which are an integral part of these machines. These gears are applied in various types of rotary machines such as: rotary pumps, rotary motors, rotary compressors and blowers. Cycloidal profiles are in use both in the design of internal and external gears.

The application of these gears in gerotor pumps, which are classified as planetary rotary pumps, as a result had numerous advantages when compared to other rotary pumps. The main advantages are:

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simple construction, versatility, lower noise level, compact construction and smaller dimensions, which resulted in saving materials and processing costs thus reducing the price of the product, etc.

In this review paper on the design of hydraulic machines with cycloidal gear, groups of papers are presented based on the following content:

- methods of generating cycloid (trochoid) gears - different approaches,
- kinematic analysis and
- dynamic analysis.

2. METHODS OF GENERATING CYCLOIDAL GEARS – DIFFERENT APPROACHES

This overview of relevant literature presents current approaches in generating gear profiles of gerotor pumps, orbital motors and new concepts.

In their paper, *A. Nag* and *R. Maiti*⁴ proposed uniting different approaches to geometric design of cycloidal gears that are available in literature and other published research papers, for a star rotor used in hydraulic machines (planetary rotary pumps and motors) GEROTOR, GEROLER and ORBIT.

Gerotors belong to the group of planetary rotary pumps and are characterized by a simple construction and versatility. In the planetary rotary pumps, the inner gear acts as a rotor, while the outer gear represents the stator. During the operation of the pump, owing to the specific geometry of the gear profile, constant contact of all teeth is ensured, which enables the necessary separation of high- and low-pressure zones. During pump operation, the rotor teeth play the role of pushing elements (pistons), while the chambers correspond to cylinders. This leads to a periodic increase and decrease in the working volume of the chambers.

Gerolers use the same operating principle as gerotors, but they use rollers instead of circular teeth. This reduces friction and wear and improves performance at low-speed, extending lifespan of the motor.

Orbital motors are characterized by very little oil leakage, as well as the ability to produce high torque output at low speeds. The rotor of an orbital motor usually has one tooth less than the stator.

The differences in the equations of the profile geometry are mainly the result of the differences in the considered generating coordinate systems. In the given study, the authors used transformation techniques, combining three different approaches with common expressions for the epitrochoid profile used in rotary reciprocating machines (*ROPIMAs*). The first approach consisted in generating, with a constant distance between the centers C_o when the epitrochoid is obtained by rolling the inner side of a larger circle on the outside of a smaller fixed circle (Figure 1). Another approach focuses on designing a cycloidal gear, where an epitrochoid is obtained by rolling a small circle on the outside of a larger circle (Figure 2). The third approach is based on the principle of generating the cycloidal profile of the internal gear by the relative movement of the circular profile of the external gear (Figure 3). With real parameter values which were used for different approaches, the authors *A. Nag* and *R. Maiti*⁵ verified their analysis by combining three different approaches.

⁴ Nag A., Maiti R., Unification of epitrochoid origin profile design approaches for external lobed star member used in hydrostatic and gear units, *Journal of Mechanical Engineering Science*, Vol. 227, Part C, No. 2, 2012, p. 299.

⁵ Ibid

Representatives of the Wrocław group assumed that the gerotor and orbital systems should be treated as gear systems. They dealt with the fundamentals of designing and manufacturing cycloidal gears and gear systems that make up gerotor and orbital systems. Their systematic research includes the geometry, kinematics, strength, hydraulics and technology of cycloidal gears. An integrated system of technical parameters, similar to the one used for classic involute gears, was used to describe those problems. Another group of researchers from the University Center of Terrassa considers the gerotor pump as a hydraulic machine, and their design of the gerotor pump achieves a balance between volumetric efficiency, manufacturability and mechanical efficiency. The third group of researchers from Kragujevac made a great contribution by conducting a detailed analysis of the influence of the geometrical parameters of the trochoid gear on the reduction of contact stress performed by the analytical-numerical method. The developed mathematical model and the obtained results can be useful to designers of gerotor pumps and motors in the process of selection of the best construction solutions that will reach a higher degree of utilization.

3. KINEMATIC ANALYSIS

This study includes a presentation of analytical methods for determining the influence of geometric and kinematic parameters of cycloidal gearing on the output characteristics of gerotor machines with the aim of improving their design.

In the paper¹⁰ *G. Bonandrini et al* discussed the original profile of rotary pumps, which has many potential advantages compared to the usual epitrochoid profile. All the necessary aspects related to the kinematics and operation of the machine are taken into account by means of a mathematical formulation. The kinematic analysis specifically considers the possible presence of transmission errors and ensures the absence of interference by analyzing the contact of the teeth. The achieved mathematical model allows the designer to obtain a complete definition of the rotor profile in a parametric form.

In their study, *S. Y. Jung et al.* gave a theoretical analysis of the operation of the pump with multiple profile shapes on the external rotor with internal teeth (ellipse 1, involute and ellipse 2) shown in Figure 4, while the profile of the internal rotor with external teeth was determined in a function of the profile of the external rotor¹¹. They created a program for automatic calculation of flow and flow inconsistencies using the proposed profile and proved better gerotor performance compared to earlier solutions.

In the paper¹², *D. Roy et al.* used the FEA technique to accurately estimate the generated deformations and clearances at the geometrically closed active contacts of an epitrochoidal generated rotor-stator, as used in hydrostatic units (*ORBIT* motors, *GEROTOR* motors and pumps and *ORBITROL* control).

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¹¹ Jung S. Y., Bae J. H., Kim M. S., Kim C., Development of a New Gerotor for Oil Pumps with Multiple Profiles, International Journal of precision engineering and manufacturing, Vol. 12, No. 5, pp. 835-841, 2011

¹² Roy D., Maiti R., Das P. K., Mechanics and FEM estimation of gaps generated in starring active contacts of ORBIT motor during operation, Springer Nature B.V., 2019

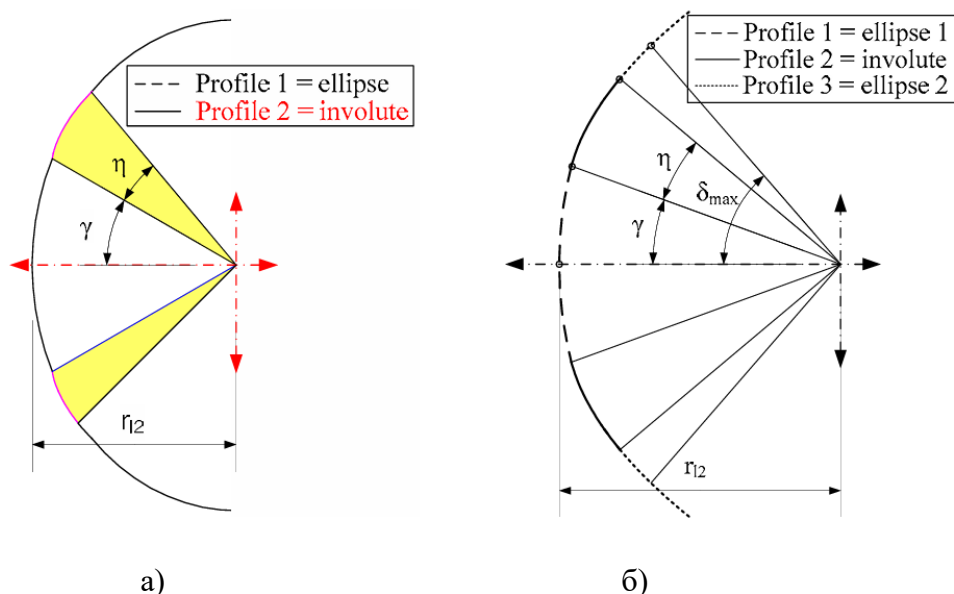


Figure 4. Comparison between the previous tooth profile and the new tooth profile a) ellipse and involute b) ellipse 1, involute and ellipse 2

Source: *Development of a New Gerotor for Oil Pumps with Multiple Profiles*, 2011, p. 835

The purpose of the study¹³, conducted by B. Paffoni was to achieve the appropriate thickness of the oil film and the pressure on the teeth in contact. He used vector analysis to accurately describe the geometry of the hydrostatic gear pump, from which he derived the general parametric equations. Based on these results, a thorough analysis is presented regarding slipping and mean speed, input torque, contact pressure and elastohydrodynamic film thickness.

A. Panchenko *et al.*, in their research¹⁴, created a developed kinematic diagram of the movement of the rotor of the orbital hydraulic motor, which enabled the substantiation of the kinematics of the movement of the rotor of the orbital hydraulic motor and the analysis of the change in its output characteristics. It was found that in the absence of a "rigid" kinematic connection between the centers of the rotors of the orbital hydraulic motor, they occupy a position in which the "self-sealing" of these rotors occurs. Research analysis of the change of output characteristics of the orbital hydraulic motor, by modeling the kinematics of its rotors, shows that non-standard changes in the output characteristics of hydraulic motors of this type include changes in the overall degree of utilization and changes in the angular speed of rotation of its shaft.

The main goal of L. Ivanović's paper¹⁵ was the study of the influence of the considered geometrical parameters on the quality indicators of the trochoid gear pair of the gerotor pump. Proper functioning and mounting of the gear pair were ensured by defined conditions for eliminating undercutting and profile interference. After that, the effect of the geometric shape on the contact stress was considered through the analysis of the equivalent profile curvature radius at the contact point.

The calculation method was defined in relation to the minimization of the equivalent curvature of the profile of the gear teeth and enabled the rapid creation of the best combination of geometrical parameters. The importance of the developed mathematical model can best be seen through the possibility of its application not only in the design of new pumps but also in the redesign of existing

¹³Paffoni B., Pressure and film thickness in a trochoidal hydrostatic gear pump, *Proc. Instn Mech. Engrs.*, Vol. 217, Part G, pp. 179-187, 2003

¹⁴Panchenko A., Voloshina A., Luzan P., Panchenko I., Volkov S., Kinematics of motion of rotors of an orbital hydraulic machine, *International Scientific Conference Energy Efficiency in Transport*, Vol. 1021, 012045, 2020

¹⁵Ivanović L., Reduction of the maximum contact stresses by changing geometric parameters of the trochoidal gearing teeth profile, *Meccanica*, ISSN 0025-6455, Vol. 51, No. 9, pp. 2243-2257, 2016

ones, and especially through the possibility of its application in high-precision design. The contribution of this paper lies in the detailed analysis of the influence of the geometrical parameters of the trochoid gear on the reduction of contact stress.

4. DYNAMIC ANALYSIS

In this part, the results of the analysis of the influence of geometry, input shaft speed, torque fluctuation and gear tooth clearance on the dynamic performance of the gerotor pump are presented.

In his paper¹⁶, C. F. Hsieh presented research of the influence of the change in the span angle (the angle between two turning points on the outer rotor tooth profile) on the performance of the gerotor pump. When the rotors have the same volume, the sealing performance of the rotor profile can be evaluated using the profile curvature difference method and results are obtained showing that the sealing remains the same at different span angles. A comparison of the results for three different span angles (20°, 30° and 40°) reveals that the higher the span angle, the higher the utilization rate, outlet pressure, outlet flow rate and fluid volume. Subsequent dynamics analysis further suggests that different span angle designs can lead to different contact force distributions on the rotor. Therefore, the research results provide useful guidelines for rotor design.

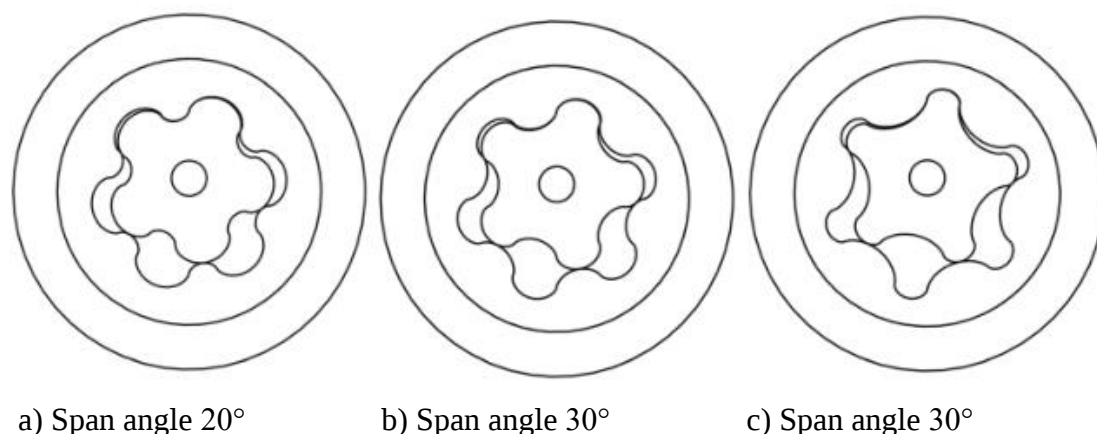


Figure 5. Rotor profiles for three different span angles

Source: *Fluid and Dynamics Analyses of a Gerotor Pump Using Various Span Angle Designs*, 2012, p. 4

In their paper¹⁷, Wang Z. *et al.* proposed a dynamic model that takes into account time-varying mesh stiffness and clearance to investigate the vibration behavior of the idle gear assembly in a gerotor pump. A test platform for the gerotor pump was also built and experiments were performed under different operating conditions including a specific inlet speed case and a ramp speed case. Based on the results of numerical simulation and experimentally measured signal, the effects of input shaft speed, torque fluctuation due to cavitation and gear tooth clearance on the dynamic performance of the gerotor pump were analyzed.

The results show that when the torque fluctuation is taken into account, the dynamic responses of the gerotor pump are modulated by the torque fluctuation. The effect of teeth clearance on the dynamic performance of a gerotor pump is limited and mainly depends on the torque fluctuation conditions. The noise of the gerotor pump is dominated by the low frequency component around the mesh frequency.

¹⁶ Hsieh C. F., *Fluid and Dynamics Analyses of a Gerotor Pump Using Various Span Angle Designs*, Journal of Mechanical Design, Vol. 134, 121003 (pages 13) 2012

¹⁷ Wang Z., Hu Z., Tian Y., Chen S., *Dynamic performance analysis of a gear transmission system due to cavitation in gerotor pump*, Journal of Low Frequency Noise, Vibration and Active Control, Vol. 0(0), pp. 1–18, 2023. <https://doi.org/10.1177/14613484231216232>

5. CONCLUSION

The main idea of this review paper was to present and point out different methods of generating trochoidal gearing in hydraulic machines. Based on the analysis of the characteristics of trochoid pairs obtained in different ways, it is recommended:

- the application of an extended epitrochoid with an outer envelope, as well as the application of an equidistant modification of the basic profile,
- introduction of modifications to reduce profile slipping at contact points,
- application of internal equidistant modification in order to reduce the dimensions and increase the working volume.

The goal of developing new rotor profiles is to increase the average pump flow rate, reduce wear and fluid resistance on the inner rotor.

Kinematic analysis enables to define the rotor profile in a parametric form by using a suitable mathematical model. It is also possible to study the influence of the considered geometric parameters on the quality indicators of the trochoid gear pair of the gerotor pump and to identify the presence of transmission errors and their elimination. The calculation method was defined in relation to the minimization of the equivalent curve of the profile of the gear teeth and enabled the rapid creation of the best combination of geometrical parameters.

By using dynamic analysis, it was determined that an increase of the span angle increases the degree of utilization, outlet pressure, outlet flow rate and fluid volume of the gerotor pump. Additionally, when designing gerotor pumps, it is necessary to take into account the effect of cavitation on the response to vibrations. The effect of teeth clearance on the dynamic performance of a gerotor pump is limited and mainly depends on the torque fluctuation conditions.

The results of the discussed research can help in the development of innovative toothing profiles of the gerotor pump in order to improve its performance, reduce energy loss and meet the challenges in designing hydraulic machines.

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26th national & 12th international conference QUALITY SYSTEM CONDITION FOR SUCCESSLFUL BUSINESS AND COMPETITIVENESS

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GIVING FEEDBACK - AN EXAMPLE OF GOOD PRACTICE IN THE AUTOMOTIVE INDUSTRY

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Abstract: *Some organizations capture the feedback and monitor its effectiveness, while others don't. Feedback is widely used across the organization as a tool of advice, as a tool for behavior, skill, or performance improvement, and employees consciously or unconsciously keep rendering feedback. Updating management systems to prioritize quality feedback is identified as a strategy to enhance organizational effectiveness and performance. This strategy operates under the hypothesis that increased performance can be achieved when employees receive frequent and high-quality feedback. This review presents an overview of the good performance feedback proven through practice.*

Keywords: *Feedback, Quick feedback, Positive, Negative, Automotive*

JEL Classification: L23

1. INTRODUCTION

There is no single definition of performance feedback. Performance feedback is the information provided for past performance⁴. Other definitions include feedback as information of previous behavior, which helps the recipient to improve or adjust current performance. Additionally, feedback is described as information given to the recipient after their behavior⁵.

Organizations are increasingly providing their employees with more frequent performance feedback⁶. This surge is driven by the widespread belief that continuous feedback can enhance employee performance. Consequently, companies are transitioning away from traditional yearly performance

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⁴ Prue, D. M., & Fairbank, J. A. (1981). Performance feedback in organizational behavior management: A review. *Journal of Organizational Behavior Management*, 3(1), 1–16.

⁵ Mayer G. R., Sulzer-Azaroff B., Wallace M. (2013). *Behavior Analysis for Lasting Change*, Third Edition

⁶ Cappelli P. and Tavis A. (2016) *The Performance Management Revolution*. *Harvard Business Review*, 10, 58-67.

appraisals and adopting ongoing feedback systems, such as touchpoint or check-in systems, as seen in the practices of GE, Deloitte, and Adobe⁷.

These changes have been facilitated by advancements in information technology systems, which have lowered the costs associated with tracking individual performance, comparing performance across employees, and disseminating this information.

2. WHAT DOES FEEDBACK MEAN?

Feedback is an essential factor in our professional lives, and at the same time, it represents a critical aspect of our actions. Proper use of feedback contributes to improving work performance because it contains indicators on how to further strengthen the strengths of collaborators and facilitates focusing on their development.

Feedback represents a complete and mutual process of positive assessments and assessments that imply further improvement. Such a process does not consider these two moments separately but as a balance established both on positive feedback and on feedback for improvement.

Why is there resistance to providing feedback? Giving feedback is often avoided due to some incorrect assumptions. The first assumption: work performance decreases if feedback requires improvement. The second assumption: feedback that requires improvement hurts others and affects workplace relationships. The third incorrect assumption: feedback signifies conflict.

Reality: Feedback enables collaborators to change their work performance quickly and efficiently. Furthermore, it is a direct indicator to them of which effects need improvement. Collaborators appreciate correct and transparent feedback because it represents an open form of communication.

3. FAST FEEDBACK

This practical method involves providing feedback to collaborators in an acceptable and productive manner. Feedback provides information that people need the most but often do not receive.

Rapid feedback is:

- Frequent: providing feedback is a continuous process and is part of our daily routine. The frequency of giving feedback must meet the needs of collaborators and the situation. Everyone has different feedback needs, so it is necessary to identify and clearly define the frequency of feedback for each collaborator individually.
- Accurate: providing correct, balanced, and appropriate information helps collaborators to change and develop. Before giving feedback, it is necessary to think, discuss assumptions, establish facts, and list them.
- Specific: one should rely on facts, not emotions. Collaborators need to be told much more than "you did this well or poorly." Managers must precisely indicate to employees what the next steps are in achieving positive results. Managers must specify the behaviors expected from employees and how to implement them.
- Timely: the closer the feedback is to the work performance, the greater its impact will be. Delaying feedback generally does not yield results.

Tips for providing Feedback:

1. More is better than less: Quality feedback is crucial for improving employee performance. Instead of sticking to a minimal amount of feedback, strive to provide as much relevant information as possible to ensure that employees have a clear picture of how they can enhance their work.
2. Seek opportunities to give feedback: Actively seeking opportunities to provide feedback demonstrates your commitment to employee development. This may involve regular

⁷ Buckingham M. and Goodall A. (2015) Reinventing Performance Management. Harvard Business Review, 4, 40-50

performance assessment meetings, as well as informal conversations and mentoring opportunities.

3. Make feedback a priority: Prioritizing feedback delivery emphasizes the importance of ongoing communication between management and employees. It can also serve as a catalyst for all employees to recognize the importance of learning and improvement.
4. Think before giving feedback: Behavior can often be perceived as either constructive or destructive depending on how feedback is delivered. Before providing feedback, consider your tone, language, and specific examples to ensure that it is constructive and motivating.
5. Remember the value of the process itself: Providing feedback not only contributes to individual employee development but also strengthens the overall organizational culture. By encouraging open and constructive communication, the organization becomes more flexible and adaptable to changes in the environment.
6. Make feedback an integral part of meetings, conversations, and memorandum: Integrating feedback delivery into everyday communication ensures that information is transmitted regularly and efficiently. This creates an atmosphere of openness and transparency in which employees feel supported and motivated to continually progress.

Incorrect ways of providing feedback can have negative consequences on the work atmosphere and employees' efficiency. Here are a few key mistakes to avoid:

- Insufficient: Providing insufficient feedback can leave employees uncertain about their work and how to improve it.
- Unhelpful: Giving unhelpful feedback that does not offer specific guidance or suggestions for improvement can frustrate employees and decrease their motivation.
- Too much at once: Overwhelming employees with too much information at once can confuse them and make it difficult for them to focus on key aspects that need improvement.
- Abruptly: Giving feedback in an abrupt or insensitive manner can trigger resistance or defensive reactions from employees, instead of encouraging constructive change.
- Excessively negative or positive: Unfairly emphasizing negative or positive aspects of work can create imbalance and compromise the objectivity of the feedback.
- Too late: Providing feedback after the opportunity for improvement has passed can be ineffective and demotivating for employees.
- Poorly documented: Lack of clear documentation of feedback can lead to misunderstandings or confusion in future performance evaluations.
- Giving feedback in anger: Feedback given in moments of anger or frustration is usually unconstructive and can damage the relationship between management and employees.

The above statement summarizes incorrect feedback practices and emphasizes the importance of a proper and constructive approach to achieve efficiency and productivity in the organization.

Lack of adequate feedback or complete absence of it can have various negative consequences on the organization and its members. Here are some possible consequences of scarce feedback:

- Collaborators become anxious and worried due to the lack of clear direction or feedback on their work, which can impact their motivation and productivity.
- Managers lose credibility when they do not provide enough feedback or ignore the needs of their teams, which can lead to a loss of trust and respect.
- Confusion may arise when employees are unsure of their tasks, goals, or expectations, leading to misunderstandings and decreased efficiency.
- Work quality may suffer due to the lack of feedback that would identify shortcomings and provide guidance for improvement, resulting in poor outcomes and client dissatisfaction.
- Collaborators miss the opportunity to learn important lessons and develop their skills when they do not receive constructive feedback, limiting their professional development.
- Errors may be repeated because the lack of feedback does not allow for corrections or process improvement.

- Dissatisfaction and resentment among employees can grow if their feedback needs are ignored or if they do not feel valued and supported.
- Missed opportunities for improvement and innovation may arise when the organization does not utilize feedback as a tool for identifying problems or identifying opportunities for growth and development.

4. HOW TO GIVE FEEDBACK

Giving feedback can be complex, but it is important to do it in a constructive and supportive manner. Here are a few steps that can help in giving feedback correctly:

1. Preparation: Before giving feedback, think about the goals and desired outcomes of the conversation. Prepare to be clear and specific in your messages.
2. Choose the right time and place: Select a moment when the person is available and ready to receive feedback. Also, choose a private place to ensure that the conversation is discreet and without distractions.
3. Be specific: Focus on specific situations, behaviors, or results you want to discuss. Use facts and concrete examples to support your claims.
4. Be constructive: Ensure that your feedback is constructive and motivating. Instead of just pointing out problems, offer suggestions for improvement or alternatives.
5. Be empathetic: Show understanding and empathy towards the person you are giving feedback to. Try to see the situation from their perspective and adjust your approach accordingly.
6. Listen actively: Create space for dialogue and listen to the person's views and reactions to the feedback. Active listening can help in understanding their thoughts and feelings.
7. Set goals: Discuss specific goals and steps the person can take to improve their performance or behavior.
8. Provide support: Offer support and resources that the person can use to achieve their goals. Show your willingness to work together to address challenges and enhance performance.

Should be offered a balanced vision of work performance and leadership with a focus on the benefits and possibilities for improvement. State what has been done satisfactorily and correctly, and encourage reflection on how one's own strengths could potentially be utilized in other situations.

State what has not been done and what requires changes and improvements. inquire about activities and procedures that could change or improve the situation. Ask why some other activities could have yielded better results. Ask colleagues how they think they should proceed in the future.

Explain the impact of their performance on the company, operations, and work area. Express gratitude and guarantee further support.

5. EXAMPLES OF POSITIVE FEEDBACK

Table 1. Examples of Positive feedback

What have you done in a correct and satisfactory manner?	Why is this important for the company, the environment, or person.	What did I value?
Your performance for the team was complete and well-directed.	Thanks to you, it is now completely clear why we opted for a different solution.	I value your research and the way you presented our company.
You have set good challenges for your direct collaborators and stimulated them to achieve the set goals with innovative ideas.	The company's efficiency has reached an outstanding level. The scrap rate is lower than ever.	I value your efforts to lead innovations and to question your own habits by setting high goals for yourself.

Your proactive actions towards better mastering the CAD system throughout the year have greatly contributed to the project.	This will contribute to the faster development of the XY-99 model. A new good product will be launched.	I value the way you took the initiative to independently master the system.
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6. EXAMPLES OF FEEDBACK FOR IMPROVEMENT – NEGATIVE FEEDBACK

Table 2. Examples of Negative feedback

What has not been done and what requires changes and improvements?
Based on indicators of your leadership feedback, you are not investing enough time in developing your collaborators. Assisting collaborators and managing them are fundamental aspects of their continuous development. What do you plan to do to change this behavior?
You exceeded the budget by \$50k and knew this months in advance. You did not share this information with your direct collaborators, thus not enabling them to help find a solution. How has this behavior affected the entire situation? What do you think you should have done to avoid this from happening? What do you plan to do next?
I heard your and Martin's conversation about his scrap rate. The conversation was actually a monologue driven by emotions. You issued orders to him and told him to implement your work plan, without discussing whether that responsibility even belonged to him. It is impossible for Martin to blindly follow strict orders while at the same time being encouraged for individual development and the responsibility to find a solution. What should you have done to prevent this from happening? Do you think it could happen again in the future? How can I help you improve?

7. CONCLUSION

In this study, we analyzed the importance and effects of feedback in the context of organizations and interpersonal relationships. Through a review of relevant literature and case studies, we highlighted the key elements of giving and receiving feedback correctly, as well as the consequences of its absence. Feedback has been shown to be a crucial factor in improving performance, skill development, as well as building effective teams and work atmospheres. However, for feedback to be effective, it must be timely, constructive, clear, and supportive. Additionally, it is important to adhere to certain ethical principles and rely on open communication and empathy. By understanding and applying these principles, organizations can build a productive environment that supports the continuous development of their members and achieves outstanding results. Further research in this field could further illuminate different strategies and practices that contribute to more effective feedback management, in order to enhance productivity and employee satisfaction in modern work environments.

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CASE STUDY: ADVANTAGES OF IMPLEMENTING ISO/IEC 27001 STANDARD / EXAMPLE OF A RANSOMWARE ATTACK

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Vladimir Nedić, PhD ²

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Abstract: In the contemporary digital environment, information security becomes a critical factor for the survival and success of any organization. The growing threat of cyberattacks, especially ransomware attacks, encourages companies to adopt standardized approaches to protect their information systems. One such approach is the implementation of the international standard ISO/IEC 27001, which provides a framework for information security management system (ISMS). This case study explores the advantages of adopting the ISO/IEC 27001 standard through the analysis of a specific example of a ransomware attack on an organization that had not implemented an ISMS, compared to an organization that had established and certified its system in accordance with this standard. Special focus is on how ISO/IEC 27001 can mitigate risks and impact the organization's response to information security incidents. The results of the study indicate that the implementation of the ISO/IEC 27001 standard contributes to better risk management, increased awareness of security threats among employees, and strengthening the organization's ability to recover quickly and efficiently from cyberattacks. In addition, certification under this standard can contribute to increased trust from clients and partners in the organization's information security.

Keywords: Information security, ISO/IEC 27001, Ransomware attack, Information Security Management System (ISMS)

JEL Classification: L86, M15

1. INTRODUCTION

In the digital era, information constitutes a fundamental asset for every organization, determining its competitiveness, innovation, and operational efficiency. However, this vital asset also becomes a target for cybercriminals who employ various attack techniques, such as ransomware, to extort and

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obtain financial gains. Ransomware attacks, which lock access to data or systems until a ransom is paid, have emerged as one of the most significant challenges in the field of information security, affecting various sectors, including the food industry⁴.

Faced with this threat, organizations strive to adopt strategies and standards that can assist them in managing and protecting their informational assets. One such standard is ISO/IEC 27001, which provides a framework for information security management (Information Security Management System - ISMS). The implementation of this standard allows organizations to identify, assess, and mitigate risks related to information security, as well as to demonstrate their commitment to data protection through certification⁵.

This case study explores the benefits of implementing the ISO/IEC 27001 standard in the context of ransomware attack risks, focusing on examples from the food industry and the construction sector in the Republic of Serbia. By analyzing the cases of companies that have both implemented and not implemented this standard, the goal is to provide insight into the significance and effectiveness of ISO/IEC 27001 in addressing the challenges of information security in the contemporary business environment.

2. TYPES OF RANSOMWARE ATTACKS AND GLOBAL PROTECTIVE MEASURES

Ransomware is malicious software that encrypts or blocks access to data or computer systems, demanding a ransom for decryption or reestablishment of access. Ransomware attacks have become more sophisticated, using a variety of distribution techniques, including phishing emails, malicious ads, and exploiting vulnerabilities in computer systems. This type of attack can have serious consequences, including financial loss, damage to the reputation of organizations and violation of user privacy⁶.

Ransomware refers to a type of malicious software (malware) that blocks access to data or a computer system, usually by encrypting it and demanding a ransom to decrypt it. Attackers often demand payment in crypto currencies, such as Bitcoin, to hide their identity and avoid detection. If the victim does not pay the ransom within a specific time period, the attackers can increase the ransom amount, destroy the data or publish it publicly on the Internet. Ransomware attacks can have serious consequences for the business and reputation of organizations, threaten the privacy and security of clients, partners, and employees⁷.

In contrast to traditional malware, which typically focuses on data theft or service disruption, the distinctive economic model of ransomware is centered around restricting access to data and systems until payment is received. Ransomware malware groups employ various tactics to gain initial access to target networks, providing a foundation for the deployment of encrypted payloads within a broader environment:

- Phishing stands out as the predominant infiltration tactic. Adversaries dispatch socially engineered emails masquerading as reputable entities to deceive recipients into enabling malware installation via malicious documents or links.
- Exploiting exposed internet-facing systems such as RDP and VPNs through password brute-force attacks or vulnerabilities presents another method of ransomware infiltration. Remote access services often lack the latest security patches or rely on default passwords.

⁴ Mišković, A., Tufegđžić, M., & Banković, N. (2024). Ransomware attacks: Analysis, prevention and effective defense mechanisms. In 14th International Conference on Information Society and Technology ICIST 2024. Kopaonik, Serbia

⁵ Mišković, A., Puškarić, H., & Đorđević, M. (2023). ISO/IEC 27001:2022 - Analysis and impact on information security in organizations. In 25th National Scientific and Professional Conference "Quality System - A Condition for Successful Business and Competitiveness" (pp. 150-156). Kopaonik, Serbia

⁶ Ibid 4

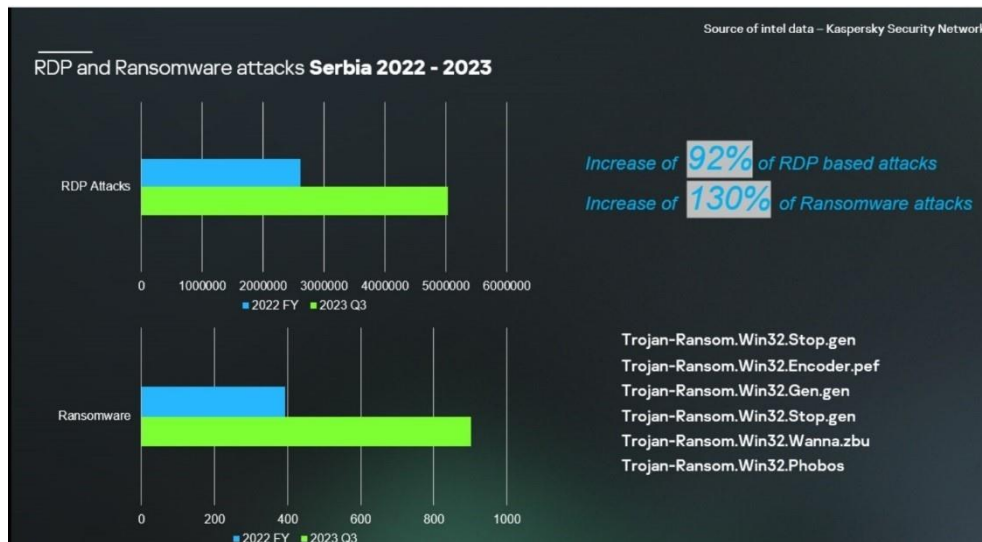
⁷ Bekkers, L., et al. (2023). Protecting your business against ransomware attacks? Explaining the motivations of entrepreneurs to take future protective measures against cybercrimes using an extended protection motivation theory model. *Computers & Security*, 127. <https://doi.org/10.1016/j.cose.2023.103099>

- Compromising external vendors and managed service providers offers soft intermediary targets for breaching into client networks using stolen credentials. Supplier access channels provide opportunities for adversaries.

2.1. RDP attacks

RDP (Remote Desktop Protocol) attacks are a type of computer system attack used to access and manage remote computers or servers over a network. These attacks typically involve attackers attempting to access the RDP port on the target computer or server, using brute force techniques to break passwords or exploiting vulnerabilities in the implementation of the RDP protocol⁸ [4].

According to the analysis conducted by Kaspersky in 2023, as shown in Picture 1, it can be concluded that the number of RDP attacks in the territory of the Republic of Serbia increased by 92% compared to 2022, while the number of ransomware attacks saw a rise of 130% compared to 2022.



Picture 1. The number of attacks via the RDP protocol in the first three quarters of 2023 in Serbia
Source: <https://esecurity.rs>

2.2. Ransomware attacks in the food industry

Ransomware attacks on the food industry have been significant and widespread, impacting many companies globally. Here are some key data points and incidents:

- Since 2018, there have been 157 confirmed ransomware attacks on the food and beverage industry, with 2021 being the most affected year, witnessing 64 attacks. These incidents have led to the breach of approximately 696,832 individual records. Ransom demands have ranged from \$20,363 to \$15 million, totaling an estimated demand of around \$637.7 million in ransoms⁹.
- In another case, Dole, a produce giant, disclosed the impact of a February 2023 ransomware attack that cost the company \$10.5 million. As the food and agriculture sector increasingly relies on internet-connected, precision technology, cyber threats to the food supplies are growing¹⁰.

These incidents highlight the vulnerability of the food industry to ransomware attacks, underscoring the importance of robust cybersecurity measures to protect against such threats. The food industry, being crucial to national security and public health, needs to adopt comprehensive cybersecurity

⁸ He, J. S., Xu, C., Zhang, Y. X., & Zhou, S. Y. (2015). A strategy for middleman attack prevention in remote desktop protocol. *Journal of Shanghai Jiaotong University (Science)*, 20, 82-85

⁹ Moody, R. (2023, June 5). Ransomware attacks on food, beverage, and agriculture organizations have cost the world economy \$1.36bn in downtime alone. *Comparitech*. Retrieved March 2024

¹⁰ Sullivan, J. (2023, July 26). America's food supplies face growing cyber threats. *Foundation for Defense of Democracies*. Retrieved March 2024

strategies, including regular system updates, employee training on phishing attacks, and securing networks against unauthorized access, to mitigate the risk of ransomware attacks.

Ransomware attacks have affected 66% of organizations in 2023. Education, construction and property, central and federal government, media, entertainment and leisure, and several other industries have been prime targets. These attacks are not only prevalent but also show a worrying trend of increasing sophistication and scale¹¹ [7].

3. ISO/IEC 27001 STANDARD AND ITS IMPLEMENTATION

ISO/IEC 27001 is an international standard for information security management that provides a framework for organizations to protect their information from various threats. This standard defines requirements for establishing, implementing, maintaining, and continually improving an Information Security Management System (ISMS). The primary objective of ISO/IEC 27001 is to protect information from unauthorized access, loss, theft, or damage, thereby ensuring the confidentiality, integrity, and availability of information. To achieve compliance with ISO/IEC 27001, organizations must identify potential risks to information security, establish appropriate control mechanisms, and implement processes for managing these risks. This includes establishing an information security policy, staff training, access control monitoring, data encryption, incident management, and regular review and assessment of the management system. ISO/IEC 27001 provides organizations with a flexible framework for managing information security that allows them to adapt to their specific needs and requirements. Obtaining ISO/IEC 27001 certification can increase client trust, improve the organization's reputation, and reduce the risks of information security-related incidents, thereby achieving a competitive advantage in the market¹².

There are four key business advantages that an organization can achieve through the implementation of this standard:

1. Meeting legal requirements - There is an increasing number of laws, regulations, and contractual requirements concerning information security, and the good news is that most of these can be addressed by implementing ISO/IEC 27001. This standard provides a perfect methodology for aligning with the aforementioned.
2. Gaining marketing advantage - If an organization obtains certification while competitive companies do not, this certification provides the organization with an advantage in the eyes of customers who are sensitive to the protection of their data.
3. Cost reduction - The fundamental philosophy of ISO/IEC 27001 is to prevent security incidents, and every incident, whether small or large, incurs costs - thus, by preventing incidents, the organization will save a significant amount of money.
4. Improved organization - Typically, rapidly growing organizations lack the time to pause and define their processes and procedures, resulting in employees often not knowing what, when, and who needs to do what. Implementing ISO/IEC 27001 helps in such situations as it encourages organizations to document their core processes (even those unrelated to security), enabling them to reduce loss and optimize employees' work time.

Under ISO/IEC 27001's information security risk assessment process in the food industry, a critical risk involves the breach or loss of sensitive information, encompassing recipes, formulations, supplier and customer data, compliance data, operational data, reputational damage, and operational disruption¹³.

¹¹ Kerner, S. M. (2023, January 26). Ransomware trends, statistics and facts heading into 2024. Security. Retrieved March 2024

¹² International Organization for Standardization. (n.d.). ISO/IEC 27001. Retrieved March 2024

¹³ Kosutic, D. (n.d.). ISO 27001 risk assessment & risk treatment: The complete guide. 27001Academy. Retrieved March 2024

4. CASE STUDY

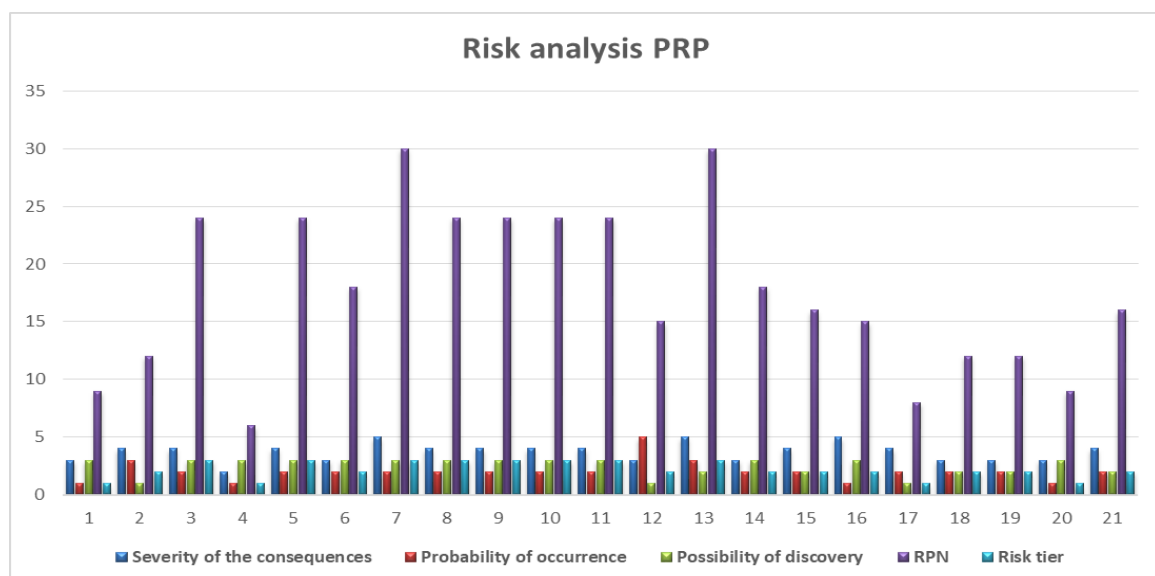
In this study, two companies will be considered for the analysis of system susceptibility to attacks: a company belonging to the food industry sector, as an example of an enterprise that has not implemented the ISO/IEC 27001 standard, and a company engaged in professional supervision and expertise in the field of construction, as an example of an enterprise that has implemented the ISO/IEC 27001 standard. Both economic entities conduct their operations and fulfill their obligations within the territory of the Republic of Serbia.

The company operating in the food industry sector has implemented the ISO 9001 standard as well as the FSSC 22000 standard, specifying them as the certification bodies defining the non-governmental organization's compliance, according to the document "Risk and Opportunity Management Procedure". This company has defined the use of the Failure Mode and Effects Analysis (FMEA) matrix as a prescribed measure related to identified risks and their application in key processes of the quality management system. Process lists for key processes refer to FMEA matrices - plans for identifying and mitigating key risks associated with the defined process, using a modified FMEA method for assessing the risks of deviations. Process owners consider these risks and take measures to minimize them. It is stated that the relative risk of deviation occurrence is determined based on three factors: severity of consequences, probability of occurrence, and detectability.

The FMEA team must make a decision regarding which risks to prioritize. This involves defining a boundary Risk Priority Number (RPN), which entails setting a certain threshold above which risks are deemed unacceptable. For all deviations with an RPN number higher than the defined threshold, it is necessary to establish appropriate measures for their resolution. On the other hand, deviations with RPN numbers below the threshold are initially not given attention. In this case, the threshold RPN number is set at 20, meaning that deviations with RPN numbers above 20 are considered unacceptable risks and require immediate implementation of appropriate measures.

The graphical representation of the Preventive Risk Plan (PRP) risk analysis is shown in Picture 2. The graph is generated from the risk matrix provided by the aforementioned company. The following parameters are defined in the matrix: PRP, risk, severity of consequences, probability of occurrence, detectability, RPN, risk ranking, required actions, and verification.

It is evident from the documentation that this company manages risks in the area of core processes but lacks documentation for managing risks in the area of data security according to the requirements of the ISO/IEC 27001 standard. Picture 2 depicts the Preventive Risk Plan (PRP) risk analysis, where the x-axis represents the number of samples, and the y-axis denotes the level of risk according to the internally defined metric.



Picture 2. Risk analysis in a food company - core processes

Values for severity of consequences, probability of occurrence, and detectability (possibility of discovery) are defined in the official documentation of the food company, while values for RPN and risk ranking are calculated using the following formulas:

- $RPN = \text{Severity of consequences} * \text{Probability of occurrence} * \text{Detectability}$;
- Risk rank: if it is $RPN \leq 10$; $RR=1$, $RPN \leq 20$; $RR=2$, $RPN \leq 35$; $RR=3$, $RPN \leq 75$; $RR=4$.

4.1. Example of an attack on a company that has not implemented the ISO/IEC 27001 standard

An example of a ransomware attack on a medium-sized company in the food industry that has been applying the ISO 9001 standard for over 20 years but has not implemented the ISO/IEC 27001 standard. The company has a large number of suppliers and produces consumer products for the markets of Serbia and neighboring countries. The company utilizes a relatively extensive implementation of Information and Communication Technology (ICT) in its business processes, with local networks across multiple locations and external access through MS VPN and RDP. Operating systems, application infrastructure, and data management systems are predominantly based on Microsoft technology. The attack was initiated through phishing emails, infiltrating via embedded OS Win XP, following which the virus encrypted databases and documents. The ransom demand amounted to 25,000 euros, to which they agreed, but they also reported the attack to the authorities. After negotiations, they obtained a decryption program, and user data was successfully recovered. As preventive measures, Kaspersky antivirus was introduced, along with external backup outside the local network, strict file opening policies, prohibition of personal device entry into the local network, and the formation of an internal team to consider the implementation of the ISO/IEC 27001 standard. Additionally, training for all employees on security activities with IT equipment was conducted.

Despite not formally initiating the implementation of ISO/IEC 27001, the company has taken measures in accordance with the recommendations of that standard.

The illustration of a sample matrix, Table 1, written according to the ISO/IEC 27001 standard, by means of which companies, regardless of whether they have implemented the standard or not, can have a defined risk management system. The table is created as a sample and does not refer to any specific real company.

How to read the matrix:

- Risk ID: A unique identifier for each risk;
- Description: A brief description of the risk;
- Likelihood: The probability of the risk occurring (Low, Medium, High);
- Impact: The potential damage the risk would cause if it occurred (Low, Medium, High);
- Risk Level: The overall level of risk, typically determined by combining likelihood and impact (Low, Medium, High);
- Mitigation Measures: Actions or controls that could be implemented to reduce the likelihood and/or impact of the risk.

Table 1. Sample risk matrix table, according to the ISO/IEC 27001 standard

Risk ID	Description	Likelihood	Impact	Risk Level	Mitigation Measures
R1	Phishing attacks leading to ransomware infection.	High	High	High	Implement regular security awareness training; deploy advanced email filtering.
R2	Unauthorized access due to weak passwords.	Medium	High	High	Enforce strong password policies; implement multi-factor authentication.
R3	Data loss from unencrypted devices.	Low	High	Medium	Encrypt all portable devices; implement device control policies.

R4	Service disruption from DDoS attack.	Medium	Medium	Medium	Deploy DDoS protection solutions; create a business continuity plan.
R5	Outdated software leading to exploitation.	High	Medium	High	Establish a regular patch management process.
R6	Theft of physical documents.	Low	Medium	Low	Secure physical storage areas; implement clean desk policies.
R7	Insider threat leading to data breach.	Low	High	Medium	Conduct background checks; apply the principle of least privilege.

Source: <https://advisera.com/27001academy/iso-27001-risk-assessment-treatment-management/>

By adhering to ISO/IEC 27001 standards, organizations can establish a robust information security management system that not only helps to prevent ransomware attacks but also prepares the organization to effectively respond and recover should an attack occur.

Creating a risk matrix is a crucial part of the risk assessment process outlined in ISO/IEC 27001, Table 1. This matrix helps organizations identify, assess, and prioritize risks based on the likelihood of their occurrence and the impact they would have on the organization. Here's a simplified example of what a risk matrix might look like for an organization implementing ISO/IEC 27001. Keep in mind that the specific risks, their likelihood, and impact will vary greatly depending on the organization's context, industry, size, and other factors.

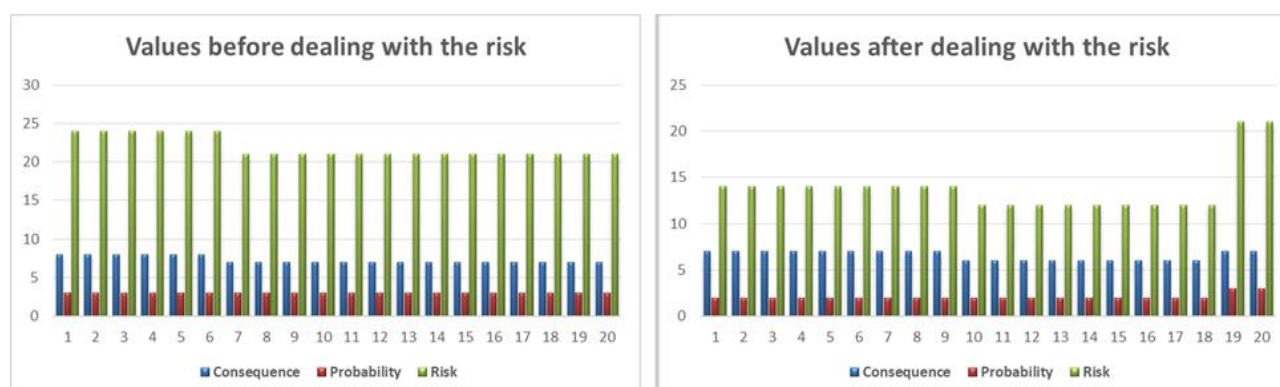
4.2. Example of a company that has implemented the ISO/IEC 27001 standard

The company, engaged in the fields of architectural design, professional supervision, and expert assessment in the construction industry, is committed to implementing and enhancing the Quality Management System, Environmental Management System, Occupational Health and Safety Management System, and Information Security Management System in accordance with the requirements of standards, as well as laws, and in line with the principles and requirements of ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, and ISO/IEC 27001:2022, along with the statement of applicability of the ISMS.

Considering the organization's context and aligning the Quality Management System (QMS), Environmental Management System (EMS), Occupational Health and Safety Management System (OH&S), and Information Security Management System (ISMS) with the company's strategic direction encompasses several key points, it involves continuous improvement of service quality to meet customer requirements and expectations, achieving leadership commitment, ongoing education for environmental protection, preservation of natural resources, prevention of workplace injuries, and improvement of EMS and OH&S efficiency, as well as continuous training of employees on information security measures. It also encompasses researching new materials with reduced environmental impact, minimizing negative impacts on water, land, air, and biodiversity, compliance with legal regulations, equipment modernization, and employee training for skills enhancement. Additionally, it includes information protection, active employee participation in planning and building trust with clients and stakeholders, identification and management of processes contributing to customer satisfaction, data-driven decision-making, and development of partnership relations. Lastly, planning and implementing measures for managing risks and opportunities to improve the efficiency of quality management systems, environmental management, occupational health and safety, as well as information security management, to enhance the design services.

In this instance, the company is cited as an example of an organization that has implemented and certified ISMS - ISO/IEC 27001 standard. The employer's goal is to implement protective measures against cyberattacks (phishing, ransomware, and other attacks). According to Picture 3, a noticeable difference can be observed before and after the risk treatment process according to ISO/IEC 27001 standardization. It is evident that the risk value (both potential and actual) has significantly decreased

after the implementation of risk treatment measures, with the x-axis representing the number of samples and the y-axis defining the level of risk according to the internally defined metric.



Picture 3. Defined levels of risk according to the internally defined metric, before and after the implementation of risk treatment according to the ISO/IEC 27001 standard

According to the documentation provided by the company engaged in architectural supervision and expertise in the construction field, a comparison of the required documentation according to the ISO/IEC 27001 standard and the attached official documentation of the aforementioned company is presented. The specified documents, or documented information, are related to security policies and in this case pertain to operational procedures.

The specified comparison is conducted in Table 2.

Table 2. Comparison of the required documentation according to the ISO/IEC 27001 standard and the attached official documentation

ISO/IEC 27001 Control Objectives and Associated Documents – required documented information	Document name in the register
ISMS Scope Document	Policy of Integrated Management System -IMS (QMS, Ems, OHS, ISMS)
Information security policy	Information Security Policies Information Security Concept Plan Data Classification by Confidentiality Level
Risk assessment and risk treatment plan	Procedure for Incident Management
Information security awareness and training	Password Usage Policy Access Control Policy Bring Your Own Device (BYOD) and Remote Work Policy
Supplier security policy	List of Licensed Software
Audit and compliance policies	Policy for Proper Use of Resources
Continuity management policies	Statement of Applicability
Clean Desk Standard Policy	Clean Desk and Screen Policy

5. CONCLUSION

Although ISO/IEC 27001 does not target industry-specific risks, the application of its framework enables organizations in all industrial sectors to systematically address the security of their information resources. By identifying and mitigating risks such as data breaches, companies can protect their intellectual property, maintain operational integrity, and preserve their reputation among consumers and partners. While some companies have adopted the ISO/IEC 27001 standard, the

majority of these companies utilize and implement only those points of the standard strictly related to information security. Consequently, in many cases, they overlook other aspects of the standard aimed at enhancing the enterprise in other respects.

As one of the rarely implemented points of the ISO/IEC 27001 standard, point 6.1 „Actions to address risks and opportunities“ stands out, which pertains to seizing opportunities and possibilities defining opportunities for business improvement, planning, and organization within a company. In addition to the mentioned point, point 10 „Improvement“ is another aspect of the ISO/IEC 27001 standard that companies tend to neglect during the standard implementation process. Namely, point 10 defines that identifying opportunities and recognizing changes can serve as a basis for continuous analysis by management to improve the information security management system. Therefore, to achieve maximum efficiency, organizations must continuously enhance their security measures and adapt them to new challenges. It is recommended to implement the ISO/IEC 27001 standard more widely across various industries, along with regular assessment and updating of security policies and procedures.

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Dean of the Faculty is prof dr Milorad Mirilović.

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TRAYAL KORPORACIJA A.D.



Trayal Corporation from Kruševac is one of the oldest companies in Serbia in the field of chemical industry. It was founded as gunpowder production factory "Obilićevo" by the decree of King Milan Obrenović from 1888, and the cornerstone was laid on Vidovdan the following year, 1889, by King Alexander I Karađorđević.

At this moment, Trayal Corporation is the largest collective in the Rasina district with a stabilized business, a large product range and five factories in its composition.

Factory of explosives, pyrotechnics and chemistry produces powder, emulsion and water-plastic explosives, matrices, boosters, anti-hail rockets, military and police pyrotechnic products, camouflage smoke, colored smoke and chemical products. It provides a complete service during the use of commercial explosives.

Factory of protective devices produces means for individual protection of the face, eyes, head, respiratory organs, hands, body and legs for use in agriculture, industry and for NBC protection, as well as a wide range of filters for protection against dust and various organic and inorganic materials. In the field of collective protection, this factory of Trayal Corporation produces vessels and water tanks, fuel tanks and filters for purification in shelters, operating rooms, pharmaceutical industry, as well as ventilation pipes for air purification in mines and activated carbon.

The two factories of Trayal Corporation are engaged in the production based on rubber processing, producing all types of tyres for bicycles, mopeds, scooters, tubes for all types of vehicles, tyres for industrial and agricultural vehicles, industrial transport and aircraft tyres.

The new factory "Obilićevo" produces thermobaric explosives and cast composite rocket fuels.

Trayal Corporation marks 133 years of work with great results.

After significant activities undertaken on resuscitation and revitalization of the company after a seven-year unsuccessful privatization that ended in December 2013, and whose consequences were faced by the new management of Trayal Corporation led by Milos Nenezić, continuity of production is ensured, which directly reflects on product quality and labour, the safety of workers and all business partners and their trust in the Corporation.

After the existing situation at the beginning of 2014, without production, without raw materials and finished products, damaged machines and facilities without funds and business systems, with continuous improvement in all segments, today Trayal Corporation occupies an important place in the economy of Serbia and the region and significantly influences the improvement of business opportunities in the country.

The entire infrastructure, facilities, machines and processes have been maintained and improved, so that they are in the function of all activities that Trayal Corporation is engaged in. Workers have been preserved as the most precious part of the system. A symbiosis was made of all segments that could be included in the vision that leads to that goal. At the same time, production was improved and new products were introduced. The idea was not only to repair the consequences, but to simultaneously develop and implement new projects, new products.

The entire debt, which after the privatization by the Bulgarian company "Brickel" was over 100 million euros, has been officially completely regulated. Trayal Corporation has no mortgages, no collateral, no bank loans. The business year 2021 ended with a historic success, the highest total income since its establishment.

The management and employees of Trayal Corporation are committed to new market-attractive development projects while constantly improving existing profitable programs.

One of the new projects of Trayal Corporation is automated anti-hail protection with the help of automatic anti-hail stations, an unmanned system that works with the help of modern equipment. It is an inestimable project that aims to eliminate damage from the hail and in that way contribute to the protection and improvement of agriculture, both for the state of Serbia and for the entire region. The system is already in use in the part of the network of radar centers in Serbia, and the equipping of all radar centers continues.

The latest project of the Trayal Corporation is the Obilićevo factory at Jasikovac, which was opened on the occasion of its 132nd anniversary, on Vidovdan 2021. With the symbolism of the name of the first factory from which the Trayal Corporation was formed, it continues the tradition as the first factory in Europe for the production of thermobaric explosives and cast composite rocket fuels. With the opening of this factory, a new, higher phase in the development of the Trayal Corporation has begun.

In addition to projects that contribute to the profitability of business, Trayal Corporation actively participates in actions to improve the living conditions of citizens, so it has been awarded many times for socially responsible business. It is the patron of three primary and three secondary schools in Kruševac, the Kruševac Public Library and financially supports the scientific development of young people in scientific centers.

Trayal Corporation is a donor of youth development in sports such as marathons, football, handball, motoring, volleyball and others.

Trayal Corporation is actively involved in the revitalization of the most famous resort in Kruševac on the mountain Jastrebac. Along with Hotel Trayal and Villa Idila, the tourist complex Jastrebac Lake Resort has sprung up, which includes one of the most attractive Adventure Parks in the Balkans, a skating rink for all seasons, an outdoor gym, a mini golf course and many other attractions suitable for mountain holidays and recreation.

Taking into account the importance of the spirituality of the Serbian people, Trayal Corporation initiated the renovation of shrines in and around the city, first Krusevac Christian church dedicated to St. George (Sv. Đorđe) and afterwards the company built two churches, one within Jastrebac Lake Resort dedicated to Christ the Savior (Crkva Hrista Spasitelja) and one in the circle of factory dedicated to St. Agathonius (Sv. Agatonik).

At this moment, Trayal Corporation is much stronger and much more promising than it has ever been in both the civilian and defence part of the first production line on the world level.

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AQP CONSULTING AGENCY

AQP agency was founded in 2007, after many years of work on consulting services and represents the Center for Quality and Business Excellence with the aim of providing services in the field of consulting, implementation of standards and education of management and employees.



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 - модул Фармацеутска технологија
- ✓ Заштита животне средине и заштита на раду:
 - модул Заштита животне средине
 - модул Заштита на раду

Одсек Аранђеловац

Основне струковне студије (3 године, 180 ЕСПБ)

- ✓ Менаџмент у туризму
- ✓ Информационе технологије
- ✓ Заштита животне и радне средине
- ✓ Примењена економија и предузетништво
- ✓ Технологија хране и гастрономија
- ✓ Графички дизајн (у припреми)

Мастер струковне студије (2 године, 120 ЕСПБ)

- ✓ Инжењерство заштите животне средине
- ✓ Туристичко пословање

Одсек Трстеник

Основне струковне студије (3 године, 180 ЕСПБ)

- ✓ Информационе технологије
- ✓ Друмски саобраћај
- ✓ Машинско инжењерство:
 - модул Хидраулика и пнеуматика
 - модул Производно машинство

Мастер струковне студије (2 године, 120 ЕСПБ)

- ✓ Информационе технологије

Време је за стручност



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SCIENTIFIC VETERINARY INSTITUTE OF SERBIA



NAUČNI INSTITUT ZA VETERINARSTVO SRBIJE Scientific Institute of Veterinary Medicine of Serbia



Ministarstvo poljoprivrede,
šumarstva i vodoprivrede
Uprava za veterinu



Zavod za zdravstvenu zaštitu

Laboratorijska dijagnostika, epizootiološki i klinički rad,
konsultativne i naučnoistraživačke aktivnosti

Nacionalne referentne laboratorije

NRL ZA SLINAVKU I ŠAP
NRL ZA BESNILO
NRL ZA AFRIČKU KUGU KONJA
NRL ZA KLASIČNU KUGU SVINJA
NRL ZA INFektivnu ANEMIJU KONJA
NRL ZA BOLEST PLAGOG JEZIKA
NRL ZA AFRIČKU KUGU SVINJA
NRL ZA VEZIKULARNU BOLEST SVINJA
NRL ZA VIRUSNI ARTERITIS KONJA
NRL ZA ENZOOTSKU LEUKOZU GOVEDA
NRL ZA BRUCELOZU
NRL ZA SALMONELOZU
NRL ZA BOLESTI RIBA



Animal health

Laboratory diagnostics, epizootiological and clinical
work, consultative and research activities

National reference laboratories

NRL FOR FOOT AND MOUTH DISEASE
NRL FOR RABIES
NRL FOR AFRICAN HORSE SICKNESS
NRL FOR CLASSICAL SWINE FEVER
NRL FOR EQUINE INFECTIOUS ANEMIA
NRL FOR BLUETONGUE DISEASE
NRL FOR AFRICAN SWINE FEVER
NRL FOR SWINE VESICULAR DISEASE
NRL FOR EQUINE VIRAL ARTERITIS
NRL FOR ENZOOTIC BOVINE LEUKOSIS
NRL FOR BRUCELOSIS
NRL FOR SALMONELLOSIS
NRL FOR FISH DISEASES

Zavod za kontrolu hrane za ljude i životinje

Mikrobiološka, fizička, hemijska, biološka, imunohemijska,
molekularna i radiološka ispitivanja.

Food and feed quality and safety control

Microbiological, physical, chemical, biological,
immunochemical, molecular and radiological analysis.



World
Organisation
for Animal
Health



Kontakt podaci
Naučni institut za veterinarnstvo Srbije, Beograd
Janisa Janulisa 14 / Smolućska 11
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Web: www.nivs.rs

TEHNOEXPORT Ltd.

The company was founded in 1953 as a family business and a small workshop.



TEHNOEXPORT

In 1992, it changed its name to Tehnoexport.

Tehnoexport is now a leading manufacturer of HVAC products, systems, and sanitary equipment.

Tehnoexport produces a wide range of HVAC products, starting from semi-flexible aluminum pipes, PVC pipes, uninsulated laminated and insulated flexible pipes. It also manufactures various types of sound dampers and additional equipment.

Additionally, Tehnoexport produces sanitary equipment, with a wide spectrum of flexible traps, floor drains, and bathroom accessories. The company operates in 50 different markets worldwide with just over 700 customers.

The mission of Tehnoexport is to become a globally recognized company in the HVAC and sanitary categories market, using modern, innovative, and quality services for its customers, to create sustainable growth for the community and the organization itself.

The vision of Tehnoexport is to become a leader in the production and sale of flexible pipes for air conditioning and ventilation needs, as well as sanitary equipment in the EU market.

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UKRAS Ltd.

This family-owned company, located in the town of Veliki Popović in the municipality of Despotovac, is engaged in the production of floor



moldings and framing, as well as the production of interior doors and other construction products.

Back in 1970, in a small carpentry workshop within the premises of their home, Zdravko Rajić, together with his wife Stanija Rajić, founded the company UKRAS. Today, UKRAS represents a company of new technologies, knowledge, and tradition, where good business practices are nurtured with a clearly defined structure, defined responsibilities, and accountability. Knowledge, experience, and a hospitable attitude towards work are successfully passed on to the second generation of owners.

UKRAS currently occupies over 5000 square meters of space and employs over 50 workers. Production is completely automated, and in its production facilities, UKRAS manufactures over 50 types of floor moldings, 300 different types of framing moldings, interior doors, and construction moldings of all shapes and dimensions.

UKRAS produces over a million linear meters of various molding profiles annually, part of which is sold through its branches - stores throughout Serbia, while the larger portion is exported to neighboring countries: Croatia, the Republic of North Macedonia, Bosnia and Herzegovina, Montenegro, as well as to Austria and Switzerland, while thanks to its distributors, UKRAS products enhance spaces in Russia, Belarus, and Kazakhstan. Negotiations with overseas countries are underway.

UKRAS is truly an adornment of the Serbian economic environment, a domestic company of domestic capital and knowledge, a company that proves that perseverance and honesty, will and desire of labor heroes and entrepreneurs lead to the future of Serbia and the Serbian economy. UKRAS, with 5 decades of experience, represents a dynamic company of modern business policies and a leading manufacturer in this region, and the greatest recognition for its work comes from customers throughout the country and the world.

The company's management is often present at fairs both domestically and internationally, ensuring that the technology at UKRAS keeps up with the latest wood processing technologies from major European companies.

Welcome to UKRAS company.

Contact details

Ukras Ltd.

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Mobile: +381 35 621 592

E-mail: info@ukras.com

web: www.ukras.com

VISOKA ŠKOLA STRUKOVNIH STUDIJA "PROF. DR RADOMIR BOJKOVIĆ"

The Higher Business School of Vocational Studies "Prof. Dr. Radomir Bojković" - Kruševac is an independent higher education institution that has been engaged in higher education activities within the educational-scientific field of social-humanistic sciences, scientific fields of Management and Business, and Economic Sciences for 31 years. The School was founded

back in 1993 as the Higher Technical School for Industrial Management. Since then, the School has undergone several transformations, and over its 31 years of existence, it has become a recognizable brand in higher education, especially in the fields of management and economics. Today, the School has evolved into a modern higher education institution equipped with all the necessary resources for conducting the teaching process, which is based on the principles of the Bologna Declaration. Currently, the School offers 4 accredited undergraduate vocational study programs:

- Management in Business-Industrial Systems,
- Economics in Business-Industrial Systems,
- Business Informatics,
- Tourism and Hospitality.

The study program Business Management for master's vocational studies is currently in the accreditation process. Since its establishment in 1993, the School has enrolled 32 generations of undergraduate vocational study students and 10 generations of specialist vocational study students. Over 5400 students have graduated, thanks to the School, raising their level of knowledge and acquiring a higher level of education, enabling them to effectively engage in business and professional activities and contribute to the development of the economy of the City of Kruševac and the Rasina District, as well as beyond.

In addition to its core activity of higher education through the implementation of first and second levels of vocational studies, the School organizes other activities such as professional projects, scientific conferences, publishing, and the development of scientific research. Over 10 domestic and international professional projects have been implemented within the scientific-professional activities. The School is the initiator of the scientific-professional journal "Business Trends," which is now categorized by the relevant ministry as a national journal of paramount importance - M51. It is also the organizer of the National Scientific-Professional Conference with international participation "Business Trends," which has been held annually since 2017, and is sponsored by the City of Kruševac



**Visoka poslovna škola
strukovnih studija**

**Prof. dr Radomir
Bojković**

KRUŠEVAC

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JELENKOVIĆ WINERY

Jelenković Winery is a small family winery founded in 2023, but one that carries with it a legacy passed down through generations, from family tradition to the glass.

Situated in the village of Stubal, Aleksandrovac Municipality, in the heart of the Župa vineyards, Jelenković Winery embodies the spirit of our region. Our passion for producing wines from domestic indigenous grape varieties, which are an inseparable part of our culture, defines the wines that come out of our cellar.



Jelenković Winery is more than just a business - it is our passion, our dedication to the land we cultivate, and the wine we produce. We cultivate and nurture domestic indigenous grape varieties that symbolize our region - Tamjanika, Prokupac, and Smederevka, with care and respect for every grape we harvest. Each variety carries the story of our region within it, and we convey it through our four labels:

SVETA JELENA: A wine that brings the scents of the past, with elegance and richness of flavor.

OSVIT: A wine that celebrates each new day, with freshness and fruity notes that capture the heart.

SUTON: A wine that invites relaxation and enjoyment, with warm hues and a layered taste.

TAMA: A wine that explores the depths of the night, with seductive aromas and complexity that mesmerizes.

Each glass of our wine is a blend of heritage, expertise, and love for viticulture and winemaking that we nurture through generations and dedication invested in every detail of our production process.

Yours sincerely,

Jelenković Winery

Contact details

JELENKOVIĆ WINERY

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PUNOŠEVAC DISTILLERY

Dear brandy lovers,

We present to you the Punoševac distillery, which recently appeared on the market and has already won the hearts of real lovers of domestic brandy. Our distillery is located in the small village Panjevac, located in the municipality of Aleksandrovac.



Our main brand is quince brandy, which is produced from the highest quality fruit that is handpicked and carefully selected from the orchards of Serbia. In the production process, we use traditional methods that have been passed down from generation to generation, with the application of modern technologies in order to obtain the perfect quince brandy..

In our distillery, we use only natural ingredients, without adding any additives or artificial flavors, so that our brandy retains the natural taste and smell of quince. Our brandy is recognized for its soft taste and balanced fruity taste, which is the result of using perfect quince fruits..

Quince brandy is carefully packaged in attractively designed bottles that are perfect as a gift for your loved ones or as a gift for business partners..

The Punoševac distillery invites you to try our products and see for yourself the quality and natural taste of our brandy. Our brandy is available in the following restaurants and cafes in Belgrade: KFT Topolska 18, Zvezdara Teatar, Marinada, Salaš vinarije Zvonko Bogdan, Fidel, Caffè ca'puccino, Caffè Wien, Steak&Wine bar. And in Kruševac, you can try our brandy at Bagdala Restaurant, Trayal Hotel, Idila Hotel and Idu dani restaurant.

We invite you to visit us and enjoy the natural taste of our quince brandy.

Your Punoševac distillery.

Contact details:

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