Analysis of the densification of a biomedical titanium alloy produced by powder metallurgy

Slokar Benić, Ljerka; Komljenović, Luka; Erman, Žiga; Jajčinović, Magdalena

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C O N T E N T S

Management of innovation processes in the organization

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Abstract: *In the changing business environment and the global understanding of the market environment, the driving force of which are increasingly demanding customer requirements, the growth of supply and services, higher competition, technological development, globalization of business, innovation is a means for the implementation of constant changes. Nowadays, success is achieved by integrating innovation into business processes, and creativity of human resources in various professions, for example, technologists, designers, economists and optimizers, which is replaced by innovation engineers, business and marketing innovators, thought innovators, innovation managers, etc., is also important for productivity support.*

Strong and agile companies thus gain a leading position on the market. By connecting the knowledge of employees, innovation strategy and business management, a management model of the innovation process was created, which takes into account the diversity of types of organizational structures of enterprises and uses the elements of the innovation climate of the enterprise. An important part of managing the innovation process is determining the elements of the innovation climate, through which innovative ideas from employees are supported and their dissemination and implementation. They must be managed on the basis of the chosen type of organizational structure of the company. By properly setting the elements of the innovation climate and aligning it with the organizational structure, enterprises can manage their processes and get more innovative ideas for implementation, thus increasing their innovation performance and achieving better competitiveness in the market.

Key words: *INNOVATION PROCESS, INNOVATION STRATEGY, COMPETITION, GLOBALIZATION, INNOVATION ENGINEERING*

1. Introduction

The basic premise of a successful company is its constant progress against the competition on the market, it follows that the innovation process in the company is one of its key attributes. The manager is responsible for the innovation process in the company, who must consistently pay attention to which decisions are beneficial for the company and, conversely, which decisions can lead the company to decline and loss of prosperity. The effectiveness of management decisions lies in how intensively and successfully they can respond to the needs of the market and the current state of the company's environment. The preparation and gradual implementation of innovative changes is called the innovation process. Its result is innovation as a realized, used and above all positive change. The task of innovation processes is to purposefully influence the reproduction of all business in accordance with the growing needs and demands of the customer and the market as a whole. The innovation process is the process of creating and spreading innovations. We understand innovation processes in business activities as the implementation of individual innovations or their sets, which ensure quantitative and qualitative changes in products, processes and the structure of the production and technical base with all economic and social contexts. Innovation processes penetrate deeply into the production-technical structure of the business sphere and thus into the process of its reproduction. For example, a new technology of any nature in industry usually affects the relevant branch of engineering and electronics and causes a certain need for raw materials and energy, is associated with investments, movement of labor forces, which further causes a chain of needs. In a broader sense, innovation processes are also large programs and projects of economic development, scientific research activity, significant actions that affect the entire business process and the reproductive process within it. In practice, the main place of innovation processes are companies, where innovations are implemented in products, technologies and other activities. Creation and management of innovation processes are fully subject to business management with all its principles. The innovation process is not random. It is controlled by a specific project or program linked vertically and horizontally in the sphere of implementation.

Improving the management of innovative development in industrial enterprises includes the creation of a new market infrastructure that would stimulate and support this mechanism, as well as perform its direct control. Therefore, the problem of rational and effective use of innovative products is of particular importance in the current socio-economic conditions of our country. It also requires the latest approaches to building a management system for innovative development in companies, improving the quality of the innovation process in companies and increasing their investment and innovation attractiveness.

2. Methodology of creation and management of innovation processes of the organization

The analysis and synthesis of theoretical knowledge serve as the basis for the creation of a general model of the creation and management of innovation processes in the company. The starting model for the creation and management of innovation processes in the company (Fig. 1) is also based on the analysis of other models and practical studies and is a general model that can subsequently be elaborated in more detail on the basis of findings from primary and secondary research. From the analyses of theoretical knowledge so far, it is clear that in each type of business there are specific conditions that must be taken into account when creating and managing innovation processes (Fig. 2) and they often change depending on the sector, type of industry, size of the company and length of time on the market etc.

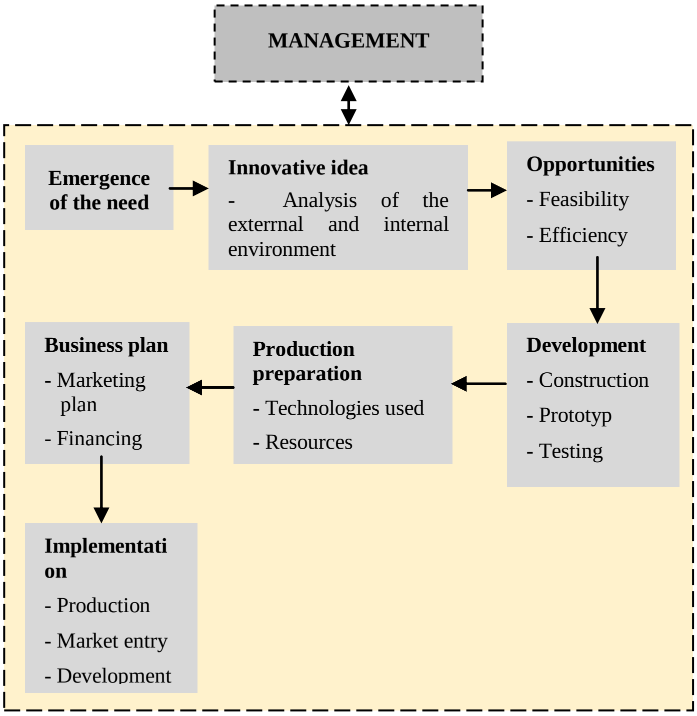

Fig. 1 *Initial model of creation and management of innovation processes in the company*

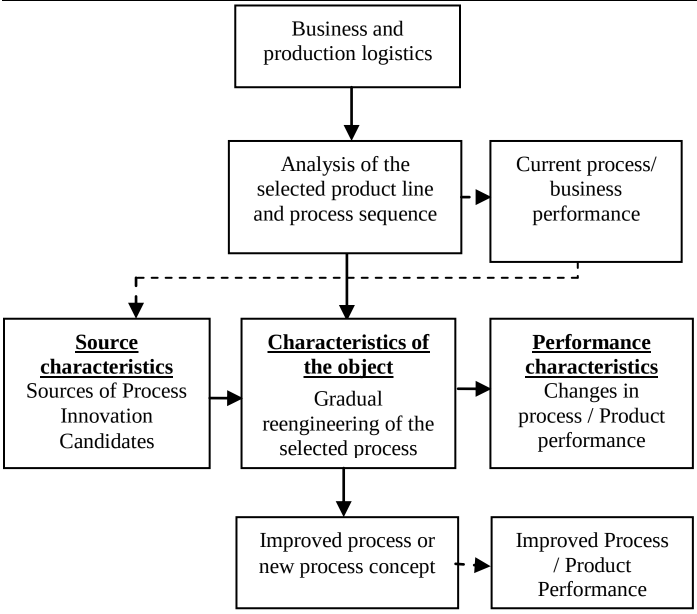

Fig. 2 *Basic model of process innovations*

Innovation is not only the use of high technology, but also a change in the field of managerial decisions. In order to realize most of the tasks faced by the enterprise, it is necessary to reorganize the enterprise management system on the basis of new management technologies. A company that wants to work flexibly inevitably comes to the need to use innovative approaches. Its essence lies in the creation of such a company management structure in which the personnel is embedded in the business process, which ensures the quality production of the product. Project management methodology plays an important role in building such a system. For this, it is necessary to develop a management system, the basis of which is the breakdown of a complex process into simple components based on a project approach and the construction of a kind of "pipeline" of management. This has a significant impact: work becomes more purposeful, requirements for personnel qualifications are reduced, labor productivity rises sharply, and the rate of errors is reduced. When designing a model for the creation and management of innovation processes in the company and based on the analysis of the state of the problem, it is necessary to take into account the following criteria [3]:

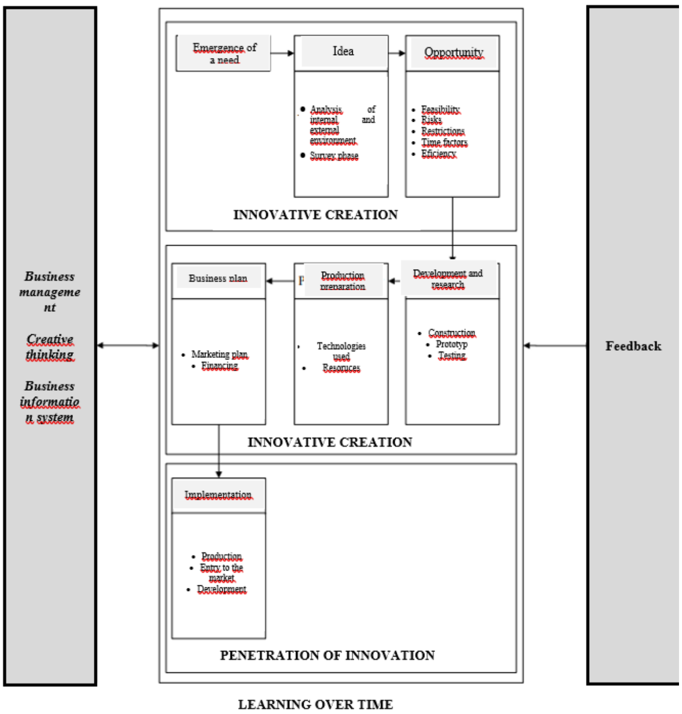

Fig. 3 *Model of creation and management of innovation processes in the company [1] [2]*

1. Openness: Flexible work with innovations that come to the company from an internal or external environment. Unused innovative ideas are registered for their possible future use through the corporate information system.
2. Cooperation: an innovation process enabling cooperation with interested parties, which significantly contribute to the improvement of the innovation process and the emergence of successful innovations. These are, for example, research institutions or universities.
3. Management elements: the course of the innovation process in the company should be effectively managed using basic managerial functions.
4. Learning from innovation: the innovation process should enable continuous improvement of its management based on learning from the implementation of the innovation process over time.
5. Feedback: on the individual stages of the innovation process, from which the company can take lessons.
6. Creative thinking: supporting the generation of innovative ideas. Emphasize creativity and creative thinking already when selecting employees and constantly support the development of creativity, for example through training.
7. Information support of the innovation process: provision of necessary information to responsible persons at the right time in the right place.

The proposed model supports working with innovative ideas, which the company acquires through stakeholders and most often from customers, employees and competitors. The proposed model is divided into three phases: creation of invention, creation of innovation, penetration of innovation and the result is innovation as a realized and used change.

The proposed model of creation and management of innovation processes in the company takes into account attributes such as management of the innovation process, openness of the innovation process in relation to interested parties, the ability to learn from the results of the individual phases in which creativity and feedback are applied.

3. Generating ideas during the standard innovation process

Based on the findings, the generation of innovative creativity ideas during the standard innovation process can be described in detail. R&D employees and group managers have the freedom to pursue their own ideas. If e.g. ten ideas, management will decide on the winning idea according to criteria such as exceptionality, feasibility and potential. Some ideas generated within the department may be presented during an appropriate event. Ideas are generated individually or in teams, and teams are usually from the same department and belong to the same work group. The idea generation process contains several stages and milestones and is a traditional stage-gate process (stage-gate process also referred to as stage-gate process or waterfall process is a technique that is initiated by the needs of the project (for example, the development of new products, development software, process improvement ,business exchanges, etc.) that is created either on the basis of new scientific discoveries or on the definition of needs by the market. Process research and development employees generate ideas all the time. If they have an idea, they can promote it only by direct contact with research and development employees [34, 48]. On the one hand, ideas can come from a specific form of professional training of workers. Efficient and motivated R&D employees thus complete specific training and can work in other departments. These employees are selected by the management. The person concerned from the R&D department will participate of this program and provide feedback about it. On the other hand, management can organize creative meetings with workers and allow R&D workers to have an environment to develop their own ideas. Therefore, ideas and innovations come from three different ways of the standard innovation process:

1. Top-down (top-down) (market pull or science pressure).
2. Expert training.
3. Creative meetings.

Ideas can be implemented into the product development or innovation process. A study may be developed to obtain additional knowledge if the potential of the idea is not clear or if the idea is not directly related to the product. One possibility is to do a feasibility study, which starts with the aim of proving the potential of the idea. Idea generation in the standard innovation process focuses on exploration and exploitation. From top to bottom, ideas are more on the exploitation side because they are based on the customer's wishes or have demonstrated very high scientific potential. On the other hand, research is the goal of a creative meeting and expert training. A standard innovation process is shown in Fig. 4.

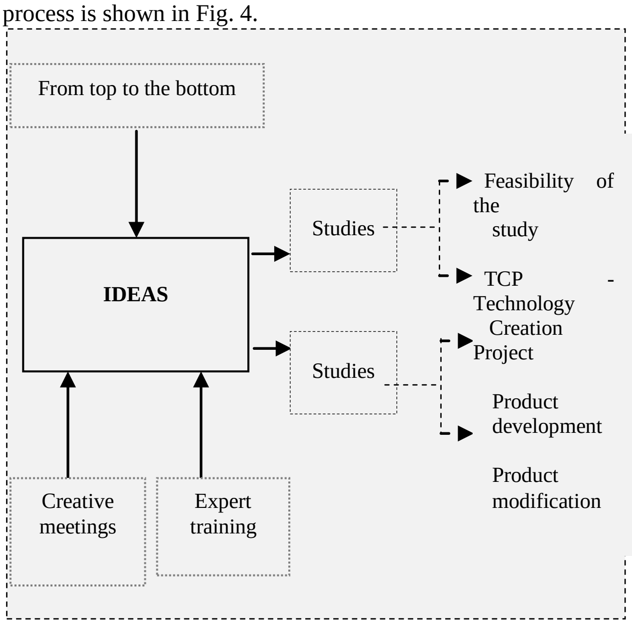

***Fig. 4** Standard innovation process*

Fig. 5 shows the process of spreading ideas and ideas within the framework of innovative creativity and the standard innovation process.

Innovation is an integral part of the development of a modern enterprise. Many new goods and services appear on the world market every day, but the average lifespan of some of them is very short. Buyers don't recognize them and they disappear from the market as quickly as they appeared. This means that they were not considered innovations, although they were new products based on interesting and original ideas. It is well known that goods and technologies have a limited lifespan. Due to its characteristics, innovative activity should be organized separately from the main production processes. In any case, it is necessary to strive to ensure the organizational flexibility of an innovative company.

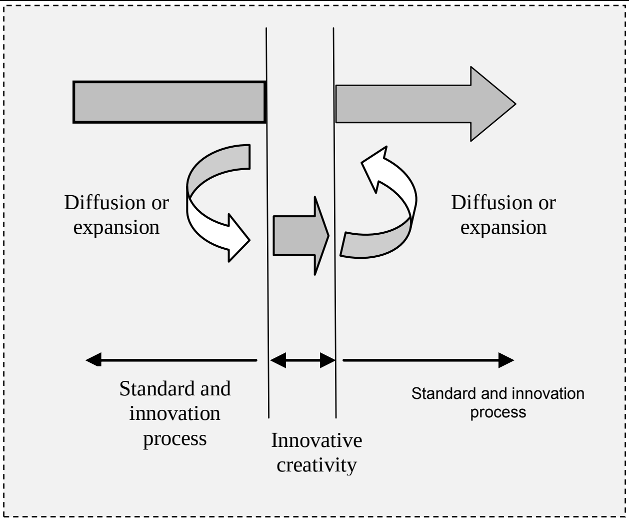

***Fig. 5** Spreading ideas or ideas*

4. Conclusion

The area of creation and management of innovation processes in the company is an increasingly discussed topic in the field of innovation. Innovations contribute to increasing competitiveness, higher sales of products or higher efficiency. If a business is really interested in innovating a product or service, it must first thoroughly examine its own processes, despite the fact that finding new products or services is more exciting. It is a common phenomenon that many parts in organizations need reengineering of company processes. The creation and management of innovation processes is a very important role for the company and its economic and social growth. Business managers are increasingly becoming aware of the importance and importance of innovation.

Product innovations represent shifts in the competitive position, which nowadays can result in a leading position in the market, even in the entire industry. In order for businesses to be successful in the long term, it is essential that they use their innovation potential to the fullest. Problems often arise that companies often encounter, such as insufficient use of innovation opportunities, the absence of a comprehensive model for the creation and management of innovation processes, the absence of a comprehensive systematic methodology for the creation or management of innovation processes. Therefore, the innovative activity of the company is considered a necessary condition for its growth and competitiveness in global markets. Increasingly demanding customer requirements, increasing competition, technological development and globalization in a changing business environment are becoming a driving force for innovation.

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Efficiency of formation and development of intrafirm knowledge in a modern market economy

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Abstract. *The set of theoretical and methodological concepts related to the formation, development and knowledge has been studied. Within the framework of the study, approaches are considered that in one form, or another belong to classical theories. The current state and problems of modern organizations in the field of knowledge formation and development are analyzed. Based on the example of Kazakhstani organizations, the main directions are used to improve approaches to knowledge management to improve the quality of labor activity and improve the qualifications of specialists of organizations. The study identified the need to develop a high-quality and flexible in-house training system, which will be relevant in modern conditions. A toolkit has been developed that contributes to the effective formation and development of knowledge of a modern Kazakhstani specialist.*

KEY WORDS: *KNOWLEDGE MANAGEMENT, COMPETENCIES, QUALIFICATIONS, PERSONNEL TRAINING SYSTEMS, COMPETENCY MODELS, ORGANIZATION*

1 Introduction

The Strategic Plan of the Republic of Kazakhstan until 2025 emphasizes the role of human capital as a factor of development in the 21st century: special attention is paid to the role of knowledge and education – training should be aimed not only at knowledge transfer, but also be flexible and systematic, forming in future specialists relevant competencies, ability to respond and adapt to change [1].

2 Methods

The results of this study were obtained by analyzing the data, during the survey of organizations in Kazakhstan. Obtained information was studied and digitized by creating a virtual archive. Respondents were interviewed through a questionnaire survey. A five-point Likert scale was used for responses.

3 Results

There is a growing body of research on the evaluation of existing knowledge management methods, systems and tools, but to date there is no unified system for assessing the results of knowledge creation and management [2].

Approaches to creation and management of learning and competence development systems in organizations can vary significantly depending on the specific area of organizational activity, but there are some common features of staff competence management in organizations of different countries, which can generally be divided into two categories: Eastern (Japanese) and Western (Euro-American) approaches. On the basis of which it is possible to define the directions of these two approaches to the system of capacity building and personnel training as:

- expanding the qualifications of specialists in order to ensure their mobility – the Japanese, horizontal system;
- advanced training of specialists within the framework of a certain professional activity of a specialist – European-American, vertical system.

The system of competence formation in an organization can be divided directly into two main categories – intra-company training of employees (the process of transferring and creating tacit knowledge) and extra-company training – increasing professional level of a specialist outside his/her "working" activity (the process of acquisition of explicit knowledge).Company training is directly connected with the practical part of an expert's activity and allows to better understand his/her position and tasks as an expert in this organization.

One of the main goals of education is to acquire a common set of knowledge, skills and other competencies to achieve the main expression of the subject of study, which in turn is necessary for self-realization and development of society as a whole.

Today there are several priority and actively developing models of education: personalized learning; lifelong learning.

Any changes in today's 21st century education system must be related to free access and the ability to disseminate human ideas and wisdom, and must be consistent with addressing economic, political, and environmental issues. Butles and Stodinger argue that a new model of society must be created in which "collective intelligence" plays an important role in decision-making and human development[3]. When training modern experts, the main task of education is to develop professional competencies and ensure that experts meet professional requirements.

Today, the competences of a modern expert include not only the ability to use "hard", professional skills, but also the so-called "flexible" competences required in forming and developing personal qualities for self-realization and sustainable development of humanity as a whole, which is reflected in the four-level model of competencies (Figure 1) [4]

There are many models of competence formation, but to date there is no universally accepted model that fully reflects all the necessary competences and classifies them. UNESCO also notes the need for a system of quality control of education and the processes associated with it for the formation and continuous improvement of competencies. Each country has its own view on the organizational chart for basic competencies. For example, Singapore considers social, thinking, informational, creative, collaborative, knowledge application, literacy, self-improvement skills, and personal character development as core competencies.

New Zealand has identified several core competencies: use of language skills, self-organization, communication and interpersonal skills, self-organization, and competent use of symbols and symbolic data.

Australia uses a model consisting of ten competencies: mastery, thinking skills, self-improvement, teamwork skills, having social and ethical skills, ability to work and apply information products and communication skills, international understanding, creativity, and quantitative thinking skills.

According to Indonesia, basic competencies can be considered knowledge, intelligence, personality traits, self-education and self-regulation skills.

Harvard Center for Curriculum Redesign (HCR), led by C. Feidl with the support of the OECD, has created a unique model of integrated educational organization, which can identify relevant competencies for the 21st century [5]. The main idea of this model is to create a new space that promotes self-learning and individual decisions about one's future. This model allows to define goals and provides a general framework for redesigning existing educational models, characterized by an increased capacity for transformation, based on information about the relevance of specific types of knowledge

Type of knowledge and skills	Examples of knowledge and skills	Duration
Contextual	Highly professional competencies that include special physical or social skills.	From a few months to several years
Cross-contextual	Highly professional competencies that include special physical or social skills. Competencies that can be applied in a larger number of areas of socio-economic and individual activity.	
Meta	Methods of operating objects in physical and objective realities. Meta- cognitive competencies include cognitive, logical, emotional and physical, as well as other types of mental abilities.	From several years to decades
Existential	Fundamental competencies that determine the essence of a person's behavior in life, his perception of situations and his character, including competencies that determine willpower, health, emotional self--regulation, abilities for self-knowledge and self-analysis, self--development skills, etc.	From decades to a lifetime

Fig. 1. *Life cycle of types of knowledge and skills [4].*

The model of CPUC reflects the interaction of four facets-dimensions among themselves within the four-dimensional model of education: in addition to traditional skills, knowledge, character a new facet appears – meta-cognition, which is an internal process of comprehension and independent adaptation of an individual's learning. The necessity of singling out meta-cognition as a separate facet is conditioned by its ability to improve the processes of using competences in the spheres beyond the conventional context.

According to D. Hacker and J. Dunlosky, metacognitive processes can be divided into 3 levels of verbalization: transformation of knowledge, transformation of nonverbal knowledge, and transformation of knowledge interpretation. Metacognition develops in the context of the student's current task and can improve the acquisition of knowledge, skills and abilities, regardless of their initial level [6].

The problem of lack of highly qualified personnel with the skills to use the latest technical and social advances constantly arises before the heads of enterprises.

According to the data obtained by Kazakhstani organizations, the distribution of employees of organizations by level of education revealed the difference between holders of a bachelor's degree (total percentage – 65.85%) and holders of secondary general education (30.49%).

The majority of employees have been with the organization for a range of 2 to 7 years. The respondents' average length of employment was 5.98 years, indicating relative stability in employee turnover among administrative and management personnel.

Despite the relative stability among the working staff, the majority of respondents indicated a desire to change jobs or dissatisfaction with the position they held. Factors such as lack of incentives in the form of career advancement or salary increases were cited as reasons. According to a survey of 264 administrative and managerial personnel in 10 organizations, operating in various fields (from industry to commerce), the majority of respondents (53,05%) are not satisfied with the additional, specialized training and professional development.

The data obtained during the survey indicate that the majority of respondents are familiar with such concepts as "knowledge", "qualification", "competence", "personnel management" (about 84.14% of respondents).

According to the survey, about 30.18% of managers are dissatisfied with the qualifications of employees in relation to their positions, 26.34% refrain from commenting, 43.48% to varying degrees are satisfied with the work of their employees.

About 75% of respondents agreed with the statement that various educational activities have a positive impact on the effectiveness of the organization.

According to numerous studies, the obsolescence of knowledge on average is about 20%, with a recommended period of acquisition of new knowledge in the industrial sector (in particular, metallurgy) every 3-4 years, and in business the period is reduced to 2-3 years.

Despite the recognition of training as a factor directly affecting the efficiency and success of the company, most organizations do not invest in the education of specialists. The main reason is that the costs are unprofitable from the economic point of view (according to the top management).

As mentioned earlier, competences are an important element of human resource management. According to M. Hitt and R. Haskisson, competences are a set of resources and capabilities of an enterprise. At the same time, the so-called key competences become a valuable source of competitive and strategic advantages [7].

Competencies can be divided into corporate competencies, which are reflected in the structure and processes of an organization and do not depend on an individual employee, and individual competencies, which belong to the employee himself and reflect the level of knowledge, skills, experience, to perform professional activities effectively.

In the strategic management literature competences are divided into core and unique competences. Core competencies are the organized internal capabilities that underlie a firm's strategy, competitiveness and profitability, while unique competencies are those that enhance an organization's competitiveness [8].

Due to the lack of a clearly articulated system for evaluating the competence of PMS specialists in organizations, we analyzed the requirements for hiring in relation to PMS.

Due to the fact that the representatives of this sphere of activity are the representatives of "mental labor" according to the results of the survey of managers and personnel the following competencies required for a specialist were identified: professional skills, strategic and critical thinking, communication, ICT-skills, result orientation, management skills.

Of course, each profession has its own peculiarities, however, in a general review of the competencies of PMS specialists, all respondent organizations came to this set of competencies.

Since the object of the study is directly administrative and managerial staff, due to the differences in the activities of organizations (from industrial to trade organizations) a general model of competencies, considering managerial, specific and basic competences of economic specialties professionals, was created (Table 1).

Table 1. *Model of key competencies of employees of administrative and managerial personnel of organizations.*

Competencies	Characteristic
1	2
Result orientation	Ability to effectively implement assigned tasks. Availability of skills that ensure the quality of work.
Customer focus	The ability to identify, analyze and provide the customer with the necessary product / service, while focusing both on the interests of the organization and on the needs of the customer. [2]
Strategic and critical thinking	The ability to holistically see the situation, analyze factors, both external and internal, that affect the success and effectiveness of an organization, department or individual, both in the medium and long term, as well as the ability to analyze the data obtained (in particular, information), on their basis, form your own vision, which serves as a guide to further actions and decision-making.
Communication and sociability	Ability to establish effective working relationships, as well as interact in other social, cultural and other contexts
ICT – literacy	Basic knowledge of digital technologies and their products (including knowledge and ability to use a personal computer and its main, as well as specialized programs)
Management skills	Ability to evaluate, plan and make decisions, taking into account all possible factors that can affect the processes in the course of the organization's activities. When holding a managerial position – also be able to analyze and regulate the activities of subordinates for their effective work.
Professional skills	Availability of knowledge, abilities, skills directly related to the performance of official duties [9].

In accordance with this model of competences, a survey was conducted among the employees of the AUP of organizations engaged in the improvement of personnel qualification and competence. Due to the difference in the required competences it was decided to separate the results of the representatives of these two specialties. To evaluate the competences the following gradation was adopted – a 4-point system – basic, average, advanced, professional. The survey took into account the opinions of managers, the employees themselves, their immediate supervisors, and colleagues. The results are presented in Figure 2;3

The analysis of the provided results showed that, on average, all indicators are within the advanced, level 3. At the same time, the data shows that several indicators of competence of employees of the organization coincide with the necessary ones. Among employees in the accounting department, these are competencies related to customer focus, communication, and management skills.
Among managers – indicators of professional skills and ICT competencies coincide with the required level. Deviations were revealed – for the indicator "customer orientation", as well as critical and strategic thinking.
The greatest deviation from the required skills was shown by ICT literacy – in all organizations. The main reasons were such factors as lack of awareness and lack of opportunities for professional development, the employees themselves either do not have the motivation or the financial capacity. Nowadays it is the development of this type of competence that should be paid special attention.

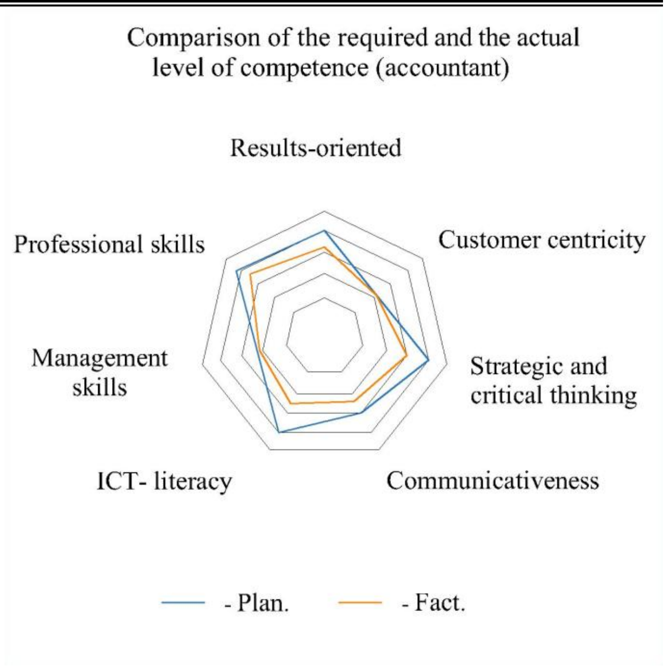

Fig. 2. *Comparative characteristics of the required and actual level of competence of specialists in the administrative and managerial personnel of the organization (accountant)*

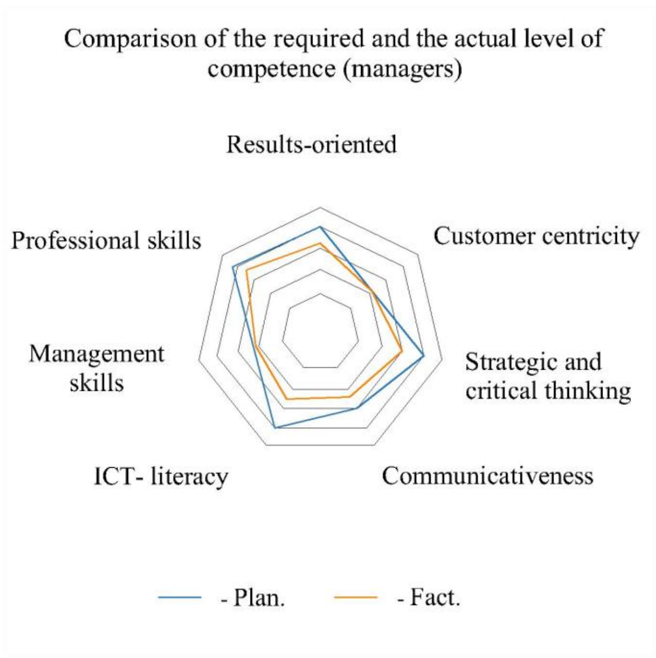

Fig. 3. *Comparative characteristics of the required and actual level of competence of specialists in the administrative and managerial personnel of the organization(managers)*

4 Discussion

A large-scale study of American companies showed that a 10% increase in spending on personnel training led to an 8.5% increase in productivity, while the same increase in capital investment led to productivity growth of only 3.8%. However, in-house professional training of personnel provides an increase in revenue along with an increase in productivity. Studies have shown that extending staff training by one year can increase GDP by another 3%. Training systems in countries such as Japan, USA, France and Korea are considered to be the most developed in-house training systems.
The adoption of the described approach by educational institutions and organizations in the development of training programs for

specialists at all levels of education will ensure that competencies meet modern requirements of employers and the labor market, will contribute to the formation of personnel with modern interdisciplinary competencies, which in turn will help to reduce the deficit.

5 Conclusion

Knowledge is becoming the center of transformation of Kazakhstan's economy and is the most important source of welfare and the key to maintaining the competitiveness of socio-economic

Knowledge becomes the center of transformation of the economy of Kazakhstan and is the most important source of welfare and the key to maintaining the competitiveness of the socio-economic development of the individual, organization and country [9].

Given the data obtained in the analysis, organizations need to develop a clear intra-company training system, which will be relevant in today's environment.

The system of intra-company training in the company should take into account everything – from increasing professionalism, experience and skills to the formation of personal qualities. The means of staff professional development can be image training in higher educational institutions, attendance of professional courses, acquisition of additional specialties, retraining courses, participation in seminars and self-education.

Lack of clearly defined model of competence prevents managers from objective assessment of specialists' competence, which is especially reflected in the system of remuneration and bonus payment. This, in turn, reduces the efficiency and effectiveness of their work and directly affects the atmosphere in the team and the activity of the organization as a whole.

Most organizations note the lack of some competences of their employees – both professional and general, but do not themselves contribute to their development and training.

For effective human resource management, the organization must also consider specific elements of knowledge management, including attention to the training and learning process of its employees, which means: creating and using an organizational culture that pays equal attention to the training and evaluation of its employees; cooperating with various educational institutions to train their professionals in the educational process with respect to the development of professional skills and professional careers. Organizations should pay attention to the training process of their professional employees, particularly the training programs and their cost, because it not only contributes to their professional development, but also helps to maintain and improve the motivation of professional employees and maintain their emotional, physical, mental, and cognitive well-being.

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A study on the external factors affecting the work of the project manager during the execution of the construction investment process

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Abstract: *The topic of the Report is a study of external factors affecting the work of the project manager in the implementation of the construction investment process.*

For the needs of the current development, a pilot study was organized and conducted by means of a survey, the purpose of which is to collect primary information regarding influencing factors on the activity of the project manager.

The partic target group of respondents are employees from the construction industry, holding various management positions in the defined companies - managers, project managers, technical managers, etc.

Various construction sites were visited and surveys conducted accordingly, both in Sofia and in the country. The companies themselves are randomly selected.

The results of the study will be presented in the report

Keywords*: PROJECT MANAGER, INFLUENCING FACTORS, SURVEY*

1. Introduction

The construction industry is the largest employer in Europe, contributing 9.9% of Gross Domestic Product and 54.9% of Gross Fiscal Capital. Nearly 15 million workers are employed in the construction sector in the European Union, which represents 6.4% of total employment in Europe and around 29% of employment in industry. In addition, 43.6 million workers depend directly or indirectly on the construction sector. The construction industry can rightfully be called one of the main drivers of the economy. The construction industry itself, as a whole, has had its peak moments and its declines during different time periods from ancient times to the present day. An example from more recent years has been the global financial crisis (2007-2008), as well as the SARS/COVID-19 Coronavirus pandemic. Unlike the financial crises that have happened before, the pandemic turned out to be something new for our times and the world was not well prepared for this kind of challenge. The pandemic has significantly affected the daily life of the entire population and has also had a heavy impact on the construction sector. According to data of the Bulgarian Construction Chamber (BCC), during the period from January 2022 until May 2022, 7.5% of the companies entered into the Professional Registry of Construction Companies have ceased their business activity. Part of the reasons for this is non-payment of internal company liabilities, as well as liabilities between companies.

According to data of the National Statistical Institute (NSI), production generated from January 2022 until March 2022 has decreased by a little over 14%. The decline of production in engineering construction was 16.4%, while in building construction – 12.4%. It was inevitable that those negative results would have their impact on the construction industry in its role as one of the economy's leading sectors. [1]

2. Study

These data are part of the reason for the organization and conduct of a pilot study in the form of a questionnaire survey, the purpose of which was to collect primary information regarding the factors affecting the project manager's activity during the execution of the construction investment process.

The defined target group of respondents consisted of employees from the construction industry, holding various management positions in the respective companies – managers, project managers, technical managers, and others.

Various construction sites were visited and, respectively, on-the-spot questionnaire surveys were performed both in the city of Sofia and in the country. In addition, questionnaire survey cards were sent and received by e-mail. The companies themselves were selected on a random basis in order to ensure greater credibility of the obtained results. The total number of surveyed respondents reached 103.

3. Processing of the obtained results

On the basis of the processed information (a sample of 30%) from the conducted questionnaire survey, provided by the respondents in the questionnaire survey cards, the following findings can be summarized.

- 91% of respondents filled in their personal data (names).
- Only 9% preferred to keep their names anonymous.

100% of respondents specified the position that they hold, the main business activity of their company, the workplace and the number of employees in the company. The respondents' workplace is mainly concentrated in the territory of the Republic of Bulgaria, where 97% of respondents work. Of them, 79% work only in the Republic of Bulgaria, while 18% work both in the Republic of Bulgaria and abroad. Only 3% of respondents are working entirely outside the country.

The respondents themselves hold various management positions in the companies that they work in, as follows:

Fig. 1 **Position**

The companies that the respondents work in are entirely from the construction industry.

13% of respondents work in companies with up to 10 employees, 25% of the companies have a workforce of 10-50 people, 34% have a workforce of 50-250 employees and 28% are companies with a workforce of more than 250 people.

According to respondents' answers, the factors affecting the activity of the project manager are grouped as follows:

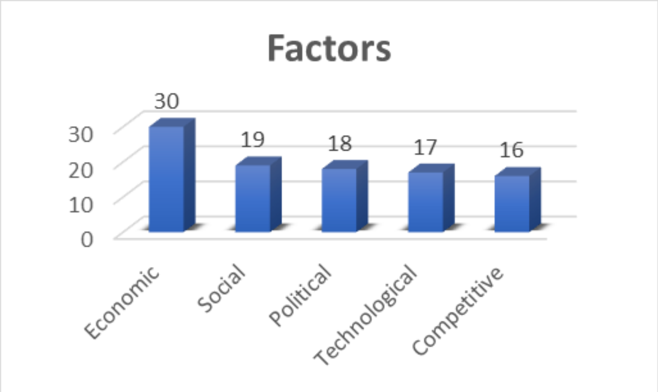

Fig. 2 **Factors**

According to respondents, the negative impacts from wrong decisions of the management team/senior management are felt the most in both the macro and micro environment (72%).
25% of respondents indicated only the micro environment, while 3% specified the macro environment only.
97% of respondents also indicate that the complexity of management is influenced by the size of the company. Only 3% answered that the size of the company does not affect the complexity of management.

The companies using the methods of project-oriented management represent half of respondents – 50%. Another 38% are companies that partially use such methods. 12% of respondents indicated that they do not use such methods.

Organizations with a dedicated project management department are 44% of respondents, while 56%, or the majority of respondents, do not have such departments.

Companies that work on the execution of European Union projects are 28%, while 72% of respondents are not engaged in activities under similar projects.

Despite the fact that some of the companies do not have a dedicated project management department, they use specialized software for such purposes. 59% of respondents fully use software products, 22% use them partially and 19% answered that they do not use such products.

The opinion of 53% of respondents is that the increase in the price of almost all types of construction materials is not justified. 41% indicated the answer “I cannot make an assessment”, while according to only 6%, the increase in price is justified.

When asked about the most common problem in the execution of a project, the respondents indicated the following answers:

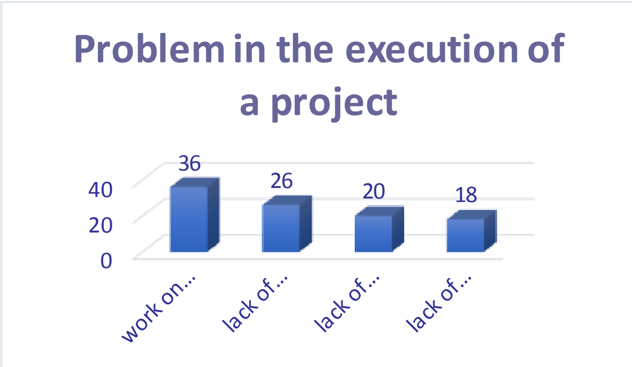

Fig. 3 problem in the execution of a project

According to 36% of respondents, work on inaccurate and incomplete projects is the most common problem. 26% indicate the lack of correct quantitative calculations as a problem, 20% – the lack of quick and adequate project design solutions, while the lack of detailed solutions for specific cases is indicated by 18%.

According to respondents, the distribution of force majeure factors that have the strongest impact on the normal course of the work process is as follows:

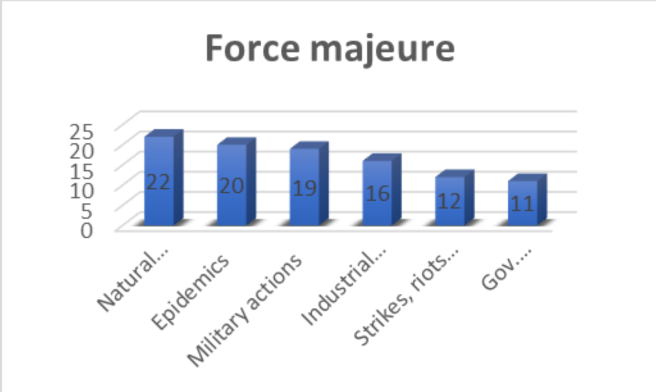

Fig. 4 **Force majeure**

The most common problems related to manpower are with the following percentage distribution:

- Lack of qualified labor – 23%,
- Speculation with the price of labor by workers – 17%,
- Insufficient number of work personnel for the needs of larger construction sites – 16%,
- Several construction sites are executed simultaneously with insufficient personnel for the volume leading to delays in the execution period – 14%,
- Request for additional payment – 11%,
- Inconsistency in undertaken commitments – 10%,
- Delay in execution – 9%.

The answers grading the negative impact regarding the actions of Contracting Parties are the following:

- Incorrect payment not meeting the prior arrangements after work completion – 11%,
- Lack of rhythmic financing of the project – 14%,
- Delay in the agreed payments – 13%,
- Frequent revisions and/or changes of parts of the project during the construction process – 12%,
- Incorrect payment not meeting the prior arrangements after work completion – 11%,
- Reluctance to update agreed prices, in relation to changes in market prices of basic materials and raw materials – 11%,
- Delay in providing decisions on specific occurring issues – 11%,
- Insufficient management and project management personnel – 11%,
- Appointment of managers who do not possess sufficient competence for the purpose – 9%.

Regarding the negative impact on the market, the provided answers are as follows:

- According to 30% of respondents, it is the rising prices of basic materials and raw materials.
- 28% indicate speculation with the price of materials that essentially should not be increasing.
- 25% indicate incorrect and disloyal partners,
- 17% of respondents indicate the decrease in the population’s purchasing power.

The most common problems with the mechanization of construction objects are:

- According to 30% of respondents, it is the outdated and amortized equipment.
- 27% indicate the frequent repairs of mechanization equipment,
- 24% indicate the lack of qualified operators,
- 19% are the respondents who are of the opinion that if the equipment is very modern, there are often no qualified operators to work with it.

The question regarding force majeure circumstances is the following: When a force majeure circumstance occurs, which team member takes the most active participation for the avoidance of its negative impact on the normal work process flow?

The provided answers are graded as follows:

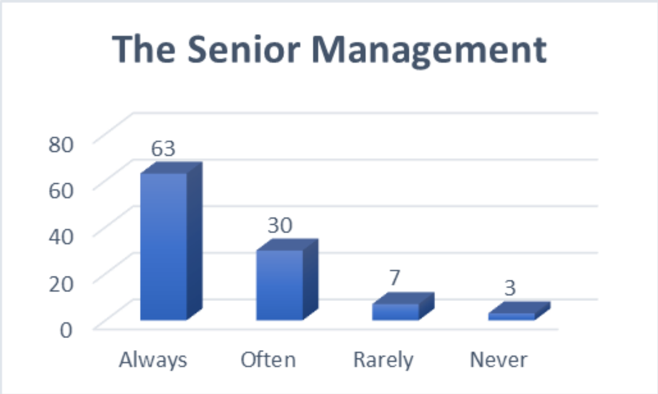

Fig. 5 **The Senior Management**

Fig. 6 **The Project Manager**

Fig. 7 **The Technical Manager**

Fig. 8 **The workers**

According to respondents' answers, most often a force majeure circumstance has an impact:

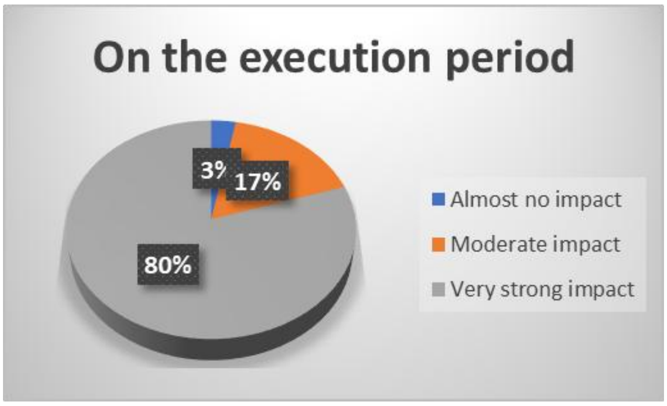

Fig. 9 **On the execution period**

Fig. 10 **On the final price**

Fig. 11 **On the quality of execution**

Survey respondents classify the Coronavirus COVID-19 pandemic, which has spread on a global scale, into the following unforeseeable circumstances:

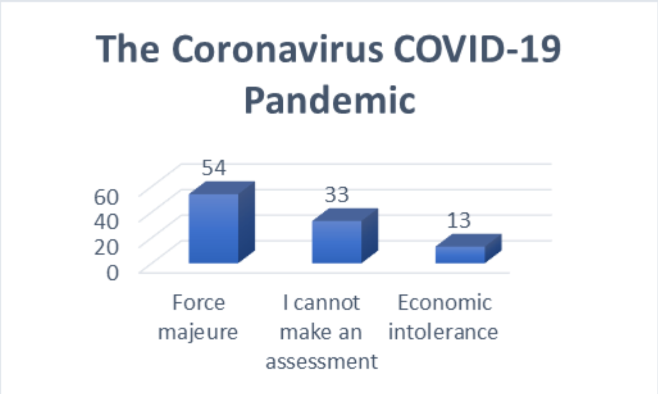

Fig. 11 **The Coronavirus COVID-19 pandemic**

4. Conclusions

- Respondents are generally willing to provide personal information such as names, workplace, work position, as well as the number of employees in the company/organization in which they work. The number of respondents who did not fill in this information is small.

- Most of the companies are working within the territory of Bulgaria. It is understandable that most companies in the country do not possess a large workforce. On the one hand, this is due to the fact that there is not such a large quantity of big projects under construction that would provide constant commitment and employment to such companies. Of course, there are exceptions, and there are such large organizations and enterprises, but they are a much smaller percentage against the background of multiple micro- and medium-level construction companies.

- The provided answers make it clear that economic factors have the strongest impact on the work of the project manager. They are followed by social, political, technological and competitive factors. However, it is noticeable that the other groups of factors are very close and with minimal differences in their percentage points, which means that practically all factors have a negative impact on the activity of the sector.

- The negative impacts of wrong decisions by the organization's top management are felt most strongly both in the micro environment and in the macro environment.

- The complexity of management is definitely influenced by the size of the enterprise. This is most often determined by the fact that we work with a large volume of human resources and its governance and management become more complicated.

- Half of the companies fully use the methods of project-oriented management, while another part uses them partially. However, it is noticeable that the larger and main percentage of companies makes full use of the advantages that this kind of management provides.

- Some of the companies also have separate project management departments. The majority do not have such departments. This is explained by the fact that most companies are small- and medium-sized enterprises and do not have such a volume of work that would allow them to designate and to maintain such a specialized department. However, such companies use specialized software for project management to a greater or lesser extent. It can be seen that such software is widely applicable and used on an almost mass scale.

- Regarding the price increase of almost all construction materials, the majority of respondents are of the opinion that such a price increase is not justified. There are products and materials that do not imply an increase in their price, but have nevertheless become more expensive. This also includes the remaining available stocks that were procured at one price, but were sold speculatively at a much higher one, without their procurement price having actually increased. This leads to large and unforeseen costs in the construction process.

- Another issue that accompanies the project manager's activity is work on inaccurate and incomplete projects and construction plans. The lack of correctly prepared quantitative calculations is also of great importance. The lack of timely and adequate project design decisions is also a factor that slows down the construction process.

- Force majeure circumstances are defined in detail, but the two most clearly defined factors that have a direct impact are natural disasters and epidemics. They are followed by military actions, accidents, strikes, riots and civil disorder, and government prohibitions (embargoes).

- Manpower issues that should be given strong attention are expressed in a palpable lack of qualified labor, speculation with the price of labor on the part of workers, difficulty in gathering the necessary number of workers for the needs of larger construction sites, requests of additional and unforeseen payment, inconsistency in undertaken commitments, as well as delays in the execution period and reduced quality of execution.

- On the part of contracting parties, problems are mainly in the lack of rhythmic financing of the project, frequent revisions during construction, delays in contractual payments, incorrect payment, reluctance to renegotiate prices in relation to market changes and the inflated values of offered materials, raw materials, services, and others.

- Mechanization is another problem indicated by respondents. The largest percentage of respondents specifies outdated and amortized equipment, which is accompanied by frequent repairs. A significant percentage answered that the lack of qualified operators also poses a serious problem, especially if the equipment is very new and if some kind of software is used.

- In cases of force majeure circumstances, the senior management, the project manager and technical managers are the people who take the most active participation in order to avoid or limit the negative consequences, while the workers themselves take no active participation, or take active participation only rarely.

- A force majeure circumstance has the greatest impact on the execution period, a moderate impact on the final price and almost no impact on the quality of works execution.

- The Coronavirus COVID-19 pandemic is most often considered as a force majeure circumstance. A very small percentage of respondents define economic intolerance as a force majeure circumstance.

The complete processing of the questionnaire survey cards as well as a factor analysis of the results will be prepared and presented in a subsequent report.

Literature:

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Risk Driven Design of Technical Product

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Abstract: *Technical Products that companies put on the market must be competitive and must find their way to the customer or the customer must find their way to them. In the vast majority, these are new products or innovated existing products that can offer the customer added value compared to the competition and, above all, induce in him the desire to purchase the product and not just include it in the selection of other competitive products. During the development process of these products, it is necessary to take into account the entire life cycle of the product and not only its operational functions and other operational characteristics, which is quite often neglected. There exist a lot of engineering design methodologies, methods and/or tools implemented in guidelines and standards which help engineering designers to innovate products and to reduce constructional, safety, environmental, etc. risks of Designed (future) Technical Products. Their common feature is especially high dependence on specialized experience of their users, time consuming, and their mutual both conceptual and terminological inconsistency resulting in very difficult compatibility with engineering designing itself.*

Keywords*: RISK, INNOVATION, EDSM, THEORY OF TECHNICAL SYSTEMS*

1. Introduction

The issue of innovation is a current global topic and is one of the key factors for a company's success on the market. It must be remembered that if "we (our business) don't do it, someone else will". Product life cycles are constantly shortening, new products must be introduced more and more often. The previously usual "development push (PUSH)" approach is changing to "market pull (PULL)". PULL innovations are those innovations that should be introduced to the market to gain an edge over the competition. A "PULL" innovation can be created by timely and appropriate prediction of properties on an existing (current) Technical Product, and based on this prediction, a qualitatively better product can then be developed. Practice initiates innovation only in relation to operation. Therefore, traditional innovations are mainly focused on improving operational functions.

The Technical Products that companies put on the market must be competitive and must find their way to the customer or the customer must find their way to them. In the vast majority, these are new Products (or innovated existing Technical Products) that can offer the customer added value compared to the competition and, above all, induce in him the desire to purchase the product and not just include it in the selection of other competitive products. During the development process of these products, it is necessary to take into account the entire TS(s) Life Cycle of the Technical Product and not only its operational functions and other operational characteristics, which is quite often neglected.

2. Problem formulation

At the beginning it was necessary to map and analyze at a basic general level the issue of technical product innovations with the aim of identifying options for increasing their effectiveness and, within the limits of possibilities, effectiveness. In the professional literature, one can find a large number of methods whose goal is higher efficiency and quality of the new product development process and improvement of either the entire innovation process or some of its parts (Fig.1). Some methods can be used for the entire process of technical product innovation (from the initial idea to the launch of the product on the market), some can be used only for a part of this process, e.g. the construction process. There is also problem to avoid risk situation(s) of the Technical Product in their Life Cycle (LC) generally.

In the professional literature[8,9], one can find a large number of methods whose goal is higher efficiency and quality of the new Technical Product development process and improvement of either the entire innovation process or some of its parts. Some methods can be used for the entire process of Technical Product innovation (from the initial idea to the launch of the product on the market), some can be used only for a part of this process, e.g. the Design Engineering Process. The goal of our paper is to present methodology which was created as synthesis between innovation methods and methods for risk analyses and elimination as obligatory procedure in several industrial branches when designing Technical Product. Risk analyses are requested often because of certification process mostly by public authority i.e. Chemical industry, nuclear engineering, automotive, healthcare,...

The above and other well-known innovation methods are mainly based on an instructive ("directive") strategy of using knowledge with a significant use of the intuitive strategy, or and the trial-error/success strategy (Fig. 1) [5]:

The instructional strategy is based on guidelines, rules and recommendations leading to the solution of the innovation assignment. These guidelines are based either on standards, company guidelines or are created in the form of methods or methodologies.

Intuitive strategy is based on the use of (irreplaceable, but in any case limited) expertise and experience of innovation solvers.

The trial-and-error/success strategy is applied without the use of rules, experience or methods and is based only on chance (trials).

By using a theoretically based strategy based on the knowledge "map" of Engineering Design Science (EDS) [5], it is possible to implement a "theoretical base" in all mentioned traditional strategies of knowledge support for innovation and use it to make the relevant innovation methods, which are at most at the instructional level, more effective strategy. All of the above-mentioned strategies (i.e. trial-and-error/success, intuitive, instructive) can be incorporated into the strategy of technical systems theories based on EDS, and based on this, they can be optimally combined during the new product development process, which is highly effective.

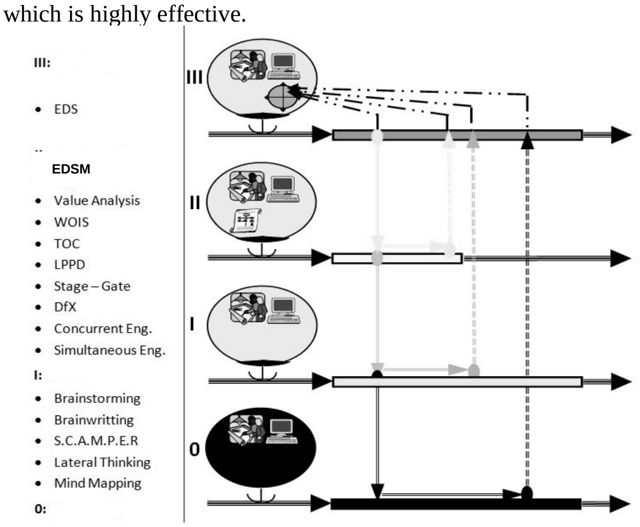

Fig. 1 *Taxonomy of methods suitable for Innovations from the level of its Knowledge support [modified 5 by authors]*

3. Theoretical Background

The basic theoretical structure, which is based on the Theory of Technical Systems to Structures [Hubka & Eder 1988, etc.] is a model of an (artificial) transformation system (TrfS) with a transformation process (TrfP), see Figure 2. This model generally expresses that each activity (e.g. technological operation Tg) is a transformation of a transformed object, marked as OPERAND in a certain input state to OPERAND in a desired state at its output, which is achieved by direct or mediated by the effects of OPERATORS, i.e. the effects of Humans (HuS), Technical Systems (TS), Active and Reactive Environment (AREnv), Information Systems (IS) and Management Systems (MgtS) on the transformed OPERAND.

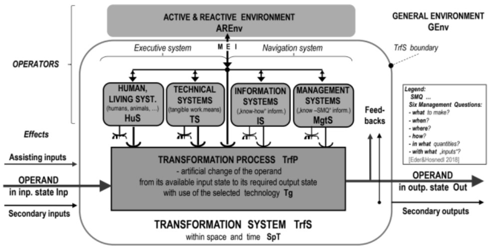

Fig. 2 *General Model of Transformation system with Transformation process* [4]

TS Life Cycle (LC) structuring can be performed according to various aspects (e.g. according to the place of implementation, according to development phases, or cost aspects, sales phases on the market, etc.), but for the needs of designing of TSs their distribution according to dominant transformations - transformation processes (TrfP) [5]. Using the general model of the Transformation system (TrfS) (Fig. 2) with its transformation process (TrfP), a general model of the life cycle of a technical product can be illustrated [2,3,4] The individual stages of the general life cycle of TS are modeled by a serial arrangement of individual stages expressed using these models.

TS life cycle is shown in Fig. 3, is distinguished by index (s) from other technical systems in individual stages. TS (s) is in the initial phase in the form of information (dashed flows), starting with production it is transformed into a material / material form (full flows). TS (s) has mainly the function of an operand, but in the operational /working phase it becomes an operator (with the exception of assisting maintenance and repair processes, when it temporarily becomes an operand). The resulting TS must meet all the requirements for its properties in terms of the entire Technical Product Life Cycle (from planning to disposal) [5].

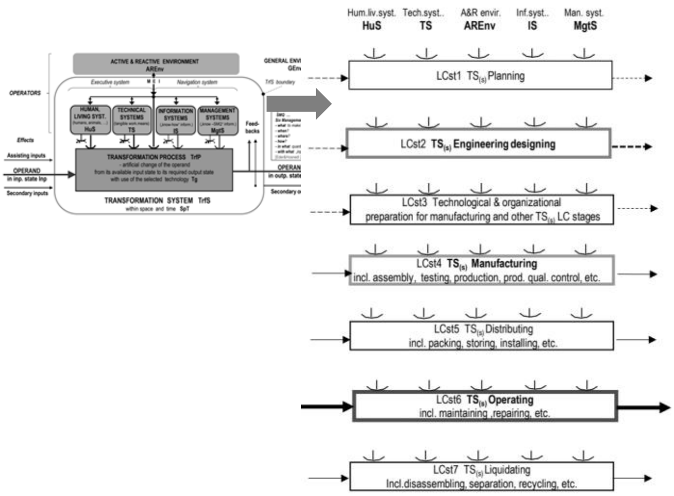

Fig. 3 *TS(s) Life Cycle stages as a sequence of the key transformation processes (TrfP) and respective transformation systems (TrfS) [7] => [2,3,4] => [5,6]*

From analysis of the generalized TS(s) LC model (Fig. 3) with proven systematic structure, it transparently shows that the carrier of R|E/S| in general, could be the following typical Object (sub) systems (ObjS):

- assessed TS (s) (i.e. reliability of TS (s) in its whole LC of TS(s), which is in professional publications, including standards, etc., moreover only with implicit or even explicit focus only on operation TS (s))

- TS (s) & ∑Human/Living Being Systems assessed (i.e. safety of TS (s) for humans and other living beings throughout the LC TS (s)), which is often incorrectly labeled in the professional publications, including standards, "only "as safety against injury / death during the operation of TS (s), moreover only with an implicit or even explicit focus only on the operation of TS (s))

- assessed TS (s) & ∑other TS (i.e. safety of TS (s) for other tangible work equipment in the whole life cycle of TS (s), which is not mentioned in professional publications, etc.)

- assessed TS (s) & ∑Management systems (i.e. safety of TS (s) for management systems in the whole life cycle of TS (s), which is mentioned in professional publications etc., very unsystematically, mostly only with a focus on strategic organization management)

- assessed TS (s) & ∑Environment (i.e. safety of TS (s) for working, natural and space environment in the LC of TS (s), which is mentioned in professional publications, incl. standards, but not systematically)

- assessed TS (s) & ∑Information systems (i.e. security of TS (s) for information systems in LC of TS (s), which is mentioned in professional publications, including standards, very unsystematically, mainly only with a focus on cybersecurity etc.)

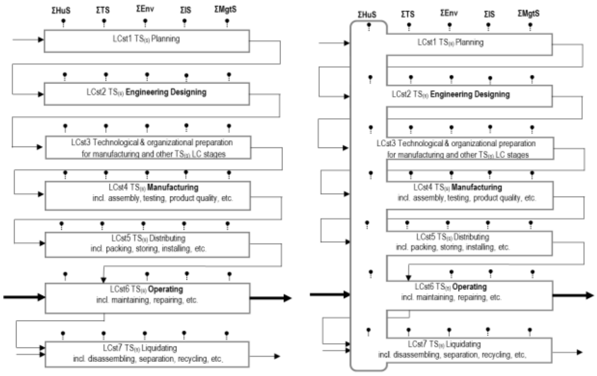

Fig. 4 *EDSM based knowledge "maps" for R|E/S| identification in the LC stages of TS (s) for Object Systems) TS (s) (left), TS (s) & ∑HuS (right) [1]*

4. Conclusion

Technical product innovations are a very current topic, as the success of their solutions determines the success and failure of individual companies. It can be assumed that with the use of knowledge based on the already successfully validated knowledge of Engineering Design Science based on the Theory of Technical Systems (EDSM-TTS) it will be possible to effectively develop and validate improved, possibly and qualitatively new innovative methods for highly creative and at the same time systematic design of innovative technical products with a higher utility value while maintaining optimal proportions: achieved quality - spent costs - spent time.

Further work will mainly be focused on the issue of disruptive innovations, which today represent the current strategy of technical product innovations and their marketing. These innovations focus on solving current problems of existing technical products. The next expected direction of work will therefore also be focused on the rational initiation of these disruptive innovations. In doing so, the use and development of the aforementioned developed software tool is envisaged to support the specification of requirements and to assess their fulfillment (SP&HA). As mentioned, disruptive innovations are mainly focused on eliminating weak points (functions and other properties) of existing technical products, which can be effectively and efficiently detected, analyzed and evaluated with the help of this SW tool.

To improve them, it will be possible to effectively use the existing knowledge and DfX (Design for X) methods, which today already cover a wide range of knowledge for achieving the required specific properties of technical products during their construction. Above mentioned methodology as a support tool for designers and employees of related engineering professions, who can comprehensively or even partially use it as feedback and control of their design activities and use this knowledge in building their own "knowledge map", which each designer creates during their practice was presented. It brings the opportunity for users use it as an effective tool for innovation and building own portfolio of knowledge, for experienced (so-called senior designers) the methodology can offer a different "perspective" on predicting the risks of technical products and confirming or refuting their routine approaches. The above presented methodology allows to perform risk prediction and analysis for object systems TS (s) & ∑HuS, TS (s) & ∑TS, TS (s) & ∑Env, TS (s) & ∑IS and TS (s) & ∑MgtS in all considered stages of the Life cycle of the designed TS or even existing TS[6].

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Evaluation of formal education active labor market policy programs in slovenia with propensity score matching

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Abstract: *In this paper, we evaluate the formal education active labor market policy programs in Slovenia during the great recession. The quasi-experimental method of propensity score matching is applied. Performance of active labor market policy programs is typically measured with the average treatment effect on the treated. In the short term, the programs do not reduce unemployment and are characterized by a high dropout rate or a high percentage of unsuccessful completions due to some problematic target groups.*
Keywords: *ACTIVE LABOR MARKET POLICY, UNEMPLOYMENT, PROPENSITY SCORE MATCHING.*

1. Introduction

The aim of this study is to evaluate an important active labor market policy (ALMP) program in Slovenia, namely Formal education. The main question that should be answered by analyzing the efficiency of active labor market policy is whether ALMP measures reduce unemployment. Unemployment is the result of imbalances in the labor market, namely the differences between the supply of labor, which is determined by demographic and social trends, and demand for labor that stems from economic activity. The unemployment rate is, at least in the short term, determined by fluctuations in economic activity, since the labor supply is rather stable. ALMP measures that would effectively reduce unemployment should affect labor supply and/or demand.

The rest of this study is structured as follows. Section 2 describes the data and variables used in the study. Section 3 explains the methodological approach of propensity score matching. In Section 4, the results of evaluating the formal education programs are explained in detail. The implications of the empirical analysis are examined in the Section 5, Conclusion. The Data and Methodological approach sections are summarized from Kavkler (2019) and from Kavkler and Volčjak (2019).

2. Data

The data for the empirical investigation were obtained from the Employment Service of Slovenia (ESS). The first database (called US as abbreviation for unemployment spells) consists of all unemployment spells that ended between 1st January 2007 and 31st December 2010, as well as all of the ongoing spells on 31st December 2010. For each of the unemployment spells, the start and end date and the variables gender, age, level of education, occupation and statistical region were made available. Because ESS is not allowed to disclose personal data about the unemployed, only a personal ID number was added to enable identification of repeated spells. 411,338 unemployment spells with positive durations are included in this database.

The second database stores data about ALMP program participants in Slovenia in the period from 2007 to 2010. This database is called AL. In addition to the variables from the US database, AL also contains information about the type of ALMP program attended by the individual, source of financing and success of the individual at completing the program. From the initial 189,924 periods, the ALMP program ended in 166,166 cases. Since the ALMP program classification changed in 2007, the study only considers the 158,546 periods according to this classification. ALMP programs were successfully completed in 122,492 cases.

When estimating the models, the study used the following variables: employment status, age, gender, level of education, region, occupation and whether this is the first job. It is important to mention other variables that are often statistically significant in similar studies of other authors, for example health status, income, marital status and number of children. Unfortunately, we were not able to obtain the data on these variables for Slovenia.

3. Methodological Approach

A statistical method of matching is used to measure effectiveness of a treatment in a population. A subset of non-treated individuals is called the control group, whereas the set of treated individuals is called the experimental group (or treatment group). For applications of matching to the labor market, population is made up of all the unemployed in a given period of time, while the treatment group consists of all individuals participating in a specific ALMP program.

Performance of ALMP programs is typically measured with the average treatment effect on the treated (ATT) that is defined below. ATT simply put represents the difference between the expected probability of employment for the experimental group and the probability in the case that given individuals from experimental group would not have participated in ALMP. The second probability can only be approximately estimated. The first step involves logit or probit models with relevant explanatory variables to calculate the propensity for participation in the observed ALMP measure. In the second step, for each individual in the experimental group, one finds one or more persons in the control group with the same or at least a similar enough propensity for participation. With this subgroup of the control group the study estimated the probability needed for ATT.

4. Results

Table 1: description of the Formal education ALMP programs (based on the Catalogue of Measures of Active Employment Policy, Employment Service of Slovenia)

GOAL AND OBJECTIVE:
Increase employability and flexibility of unemployed individuals in the labor market, reduce structural mismatch in the labor market, and raise the educational and qualification levels of unemployed individuals
IMPLEMENTATION PROCEDURE:
Inclusion is carried out based on an employment plan. Formal education includes publicly recognized educational programs that run throughout the vertical from primary school to undergraduate education. Participants who successfully complete the program obtain a publicly recognized formal education.
TARGET GROUP:
• Unemployed individuals who received education under an employment plan according to Article 53b of the Employment Relationship Act in the school year 2009/2010; • Unemployed individuals without professional or vocational education; • Unemployed individuals with health limitations; • Individuals whose employment relationship ended as redundant workers due to business reasons, bankruptcy, liquidation of the employer, or compulsory settlement and had a contract with the employer for education (in this case, the remaining costs of the education program are covered);

	• Unemployed individuals with professional or vocational education in fields in which they cannot find employment that have been registered with the Employment Service of Slovenia for more than one month, with an emphasis on eliminating regional structural mismatches in the labor market. • Unemployed individuals over 45 years of age.
DURATION OF INCLUSION:	The duration of education or inclusion of an individual depends on the type of education in which the individual is enrolled and their prior knowledge, abilities, and skills.

As the effects of formal education often manifest in the long term, we selected 1,348 formal education programs that started in 2007 as the basis. The histogram for the length of these programs, shown in Figure 1, shows that most of them (909) last up to 1 year, and the longest program was supposed to last more than 4 years and end in 2011, but it is unfortunately not in our database. We selected 519 out of a total of 909 education programs lasting up to 1 year for the experimental group, in which unemployment also began in 2007. The control group consists of individuals enrolled in vocational education in 2007 who did not participate in any of the active employment policy programs. The control group, as defined, includes 37,082 individuals.

When studying the experimental group, we noticed an unusually high percentage of unsuccessful completions. As shown in Table 1, only 56.8% of the participants successfully completed the programs, approximately 9% interrupted the education, and slightly over 32% completed it unsuccessfully (11.95% for justifiable reasons, and 20.42% for unjustifiable reasons). We suspect that the reason for such a high percentage of unsuccessful completions is due to certain problematic target groups, such as unemployed persons with health limitations and unemployed persons over the age of 45 who probably have not received any education for at least 20 years. Unsuccessful completions due to justifiable reasons are probably a result of medical certificates, so we assume that the percentage of people with health limitations in the experimental group is significant. Figure 2 shows the success rate for completions for the entire ALMP database (top figure) as well as for formal education programs (bottom figure). The ALMP database shows a 65% success rate for completions, taking into account that approximately 12% of programs were still ongoing at the beginning of the study, so there were no data on their success rate. For formal education programs as a whole, the success rate for completions is 42%, with approximately 20% unsuccessful. Some programs were not yet completed when our study ended.

The results of calculations at the end of the years 2008, 2009, and 2010 are presented in Table 3 below. The calculations were performed with R software (Sekhon, 2011). The values for ATT are negative and statistically significant in all three cases. In the short term, negative results can be expected from education because this program has a pronounced "locking-in" effect. In the long term, some foreign studies show positive results, but the target group is usually selected from all unemployed individuals. At the end of 2010, 67.24% of individuals in the experimental group were removed from the US database, and there were 9.53% more such individuals among those paired in the matching process (because ATT is -0.0953), or 76.77%. At the end of 2009, 65.13% of the experimental group were not among the registered unemployed, and at the end of 2008, this proportion was the same at 67.24%. The corresponding proportions for the matched control group are obtained by subtracting ATT from the proportion for the experimental group.

It should be noted that the calculation of ATT is biased because we do not have data on the health status of the experimental and control groups. To ensure unbiased calculation in the matching method, all variables that affect both enrollment in the ALMP program and the success of the program (i.e., removal from registered unemployment) must be controlled. Unbiased calculation could be achieved with data on some indicators of health status, such as the number of visits to a doctor by an individual in the observation period or expenditures from the health insurance fund. Currently, the obtained ATT values are too low because in the matching process, individuals with health limitations in the control group should be paired with those who also have health limitations. In any case, it would be good to reconsider the rationale for some target groups, which contribute to the high proportion of unsuccessful completions.

***Figure 1:** histogram for the length of formal education programs that began in 2007 (in years)*

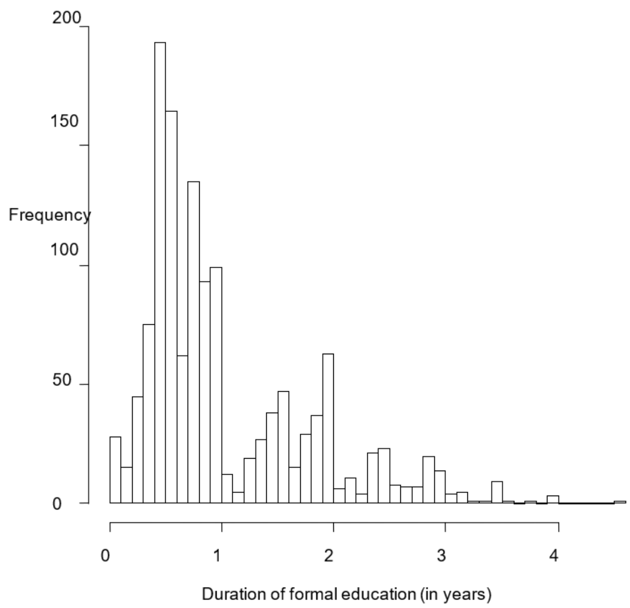
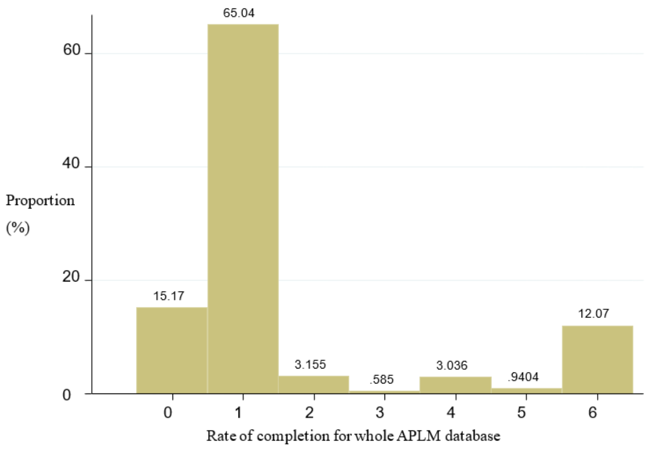
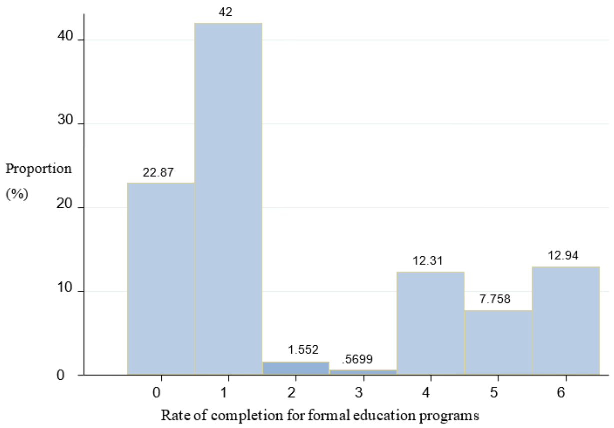


***Table 2:** Rate of completion of education for the experimental group (in %)*

No data	0.77
Successfully completed activity	56.84
Interruption of activity - justifiable reasons	6.94
Interruption of activity - unjustifiable reasons	2.31
Unsuccessfully completed - justifiable reasons	11.95
Unsuccessfully completed - unjustifiable reasons	20.42
No entry for success rate	0.77

Figure 2: *Rate of completion for the entire ALMP database (upper image) and for formal education programs (lower image)*





Legend: 0: No data, 1: Successfully completed activity, 2: Interruption of activity - justifiable reasons, 3: Interruption of activity - unjustifiable reasons, 4: Unsuccessfully completed activity - justifiable reasons, 5: Unsuccessfully completed activity - unjustifiable reasons, 6: No entry for success rate.

Table 3: *ATT calculations*

	At the end of 2008	At the end of 2009	At the end of 2010
ATT	-0,1089	-0,11247	-0,0953
AI SE	0,0234	0,022817	0,0224
t-stat	-4,6618	-4,9294	-4,2486
p-value	0,0000	0,0000	0,0000

Note: AI SE represents the standard error using the method developed by Abadie and Imbens (2006).

Formal education as an active labor market policy program has been studied by other authors. Domadenik and Pastore (2006) analyze youth unemployment in two former transition economies, Slovenia and Poland. The authors apply the multinomial logit model and argue that tertiary education lowers the probability of unemployment, especially for the young adults.

Južnik-Rotar (2008, summarized from Martin and Grubb, 2001) claims that empirical research that has investigated the effectiveness of education active labor market policy programs using a microeconometric approach has shown that such programs have a very low positive impact on the likelihood of further employment and potential earnings of program participants. Therefore, state interventions must be appropriately designed if we want to achieve greater employment opportunities for program participants and greater cost-effectiveness. Klužer (2008), on the other hand, estimates the effectiveness of active labor market policy programs with a macroeconometric approach, namely with an augmented matching function.

Caliendo and Schmidl (2016) examine youth unemployment in European countries that spend significant resources on active labor market policy programs for the young unemployed. According to the authors, a smaller part of training active labor market policy programs are »preparatory programs that promote the take-up of regular formal education, such as the continuation of general schooling, or participation in apprenticeship-based vocational education.«

5. Conclusion

Educational active labor market policy programs consist of Formal education programs and Project-based learning for young adults. These are typical attempts to reduce structural unemployment, increase employability, and flexibility on the supply side of the labor market. In the short term, the programs do not reduce unemployment; the first program is characterized by a high dropout rate or a high percentage of unsuccessful completions enrolled in formal education, and reducing unemployment is not the only goal of the project-based learning program for young adults. We assume that the reason for such a high percentage of unsuccessful completions of formal education is in some problematic target groups, such as unemployed persons with health limitations and unemployed persons over 45 years of age who have probably not been in education for at least 20 years. Unsuccessful completions due to justifiable reasons are likely a result of medical certificates, so we conclude that the percentage of persons with health limitations in the experimental group is not negligible. It would be wise to reconsider the relevance of certain target groups, which is why this program has such a high percentage of unsuccessful completions.

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Techniques for studying customer attitude to service provided

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SUMMARY: *Customer satisfaction is a priority for any business that wants to be successful over a long period of time. Feedback from customers who share their opinion about the products and services offered by the company gives a complete picture that can be used for precise planning, statistics and implementation of new aspects in the service. The purpose of this article is to present some techniques for processing data obtained from customer feedback.*
***KEY WORDS :** CUSTOMER, SERVICE, SURVEY, SMALL AND MEDIUM ENTERPRISES*

INTRODUCTION

In the fast changing business world of today, innovation has become the mainstay of organizations. The nature of global economic growth has been changed by the speed of innovation, which has been made possible by rapidly evolving technology, shorter product lifecycles and a higher rate of new product development. The complexity of innovation has been increased by growth in the amount of knowledge available to organizations [1].

But here comes the next question: how to improve the quality of customer service? Because even the rapid introduction of innovations is pointless if the level of customer satisfaction is not taken into account. Below will be described some scientists who deal with the questions of customer satisfaction and ways to measure it.

1.Thurston scale

Thurston scale, which was proposed by the American psychologist Louis Thurstone (Louis Leon Thurstone, 1887–1955) in 1928. It allows measuring the socio-psychological characteristics of the respondent on the basis of a preliminary measurement of his judgments. The answers to the questions are binary (two): (1) Agree and (2) Disagree

1.1. Definition

The Thurstone scale is defined as a unidimensional (interval) scale that is used to track a respondent's behavior, attitude, or feelings toward a subject. This scale consists of statements about a specific question or topic, each statement having a numerical value that indicates the respondents ' attitude toward the topic as favorable or unfavorable. Respondents indicate the statements they agree with and a mean value is calculated. The mean score of agreement or disagreement is calculated as the respondent 's attitude towards the topic.[10]

1.2. Constructing the Louis Thurstone scale

During the construction of the scale, one goes through the following stages , indicated in Fig. 1.:

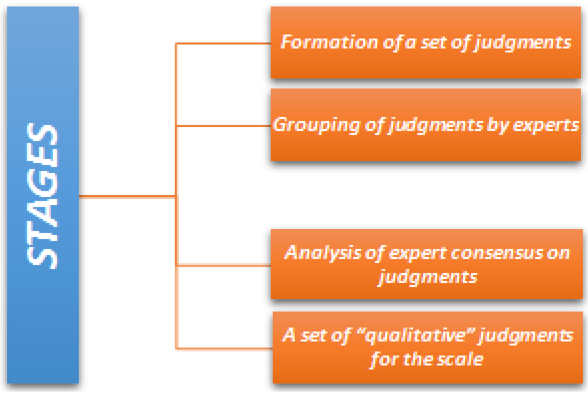

Fig. 1. Stages in the construction of the Louis Thurstone scale , [5,8]

This scale was developed by Robert Thurstone for approximate measurement in equally spaced levels . The Thurstone scale is built on the foundations of the Likert scale, but this method of constructing an attitude scale not only takes into account the value of each item while evaluating the final attitude score, but also takes care of the neutral items. Steps in Thurstone Scale Research

An example of Thurstone's large-scale research is to understand the attitudes of employees in an organization toward hiring people of diversity in that organization. There are 2 different stages in the Thurstone scale question:

First stage - to bring up the final questions, fig.2.:

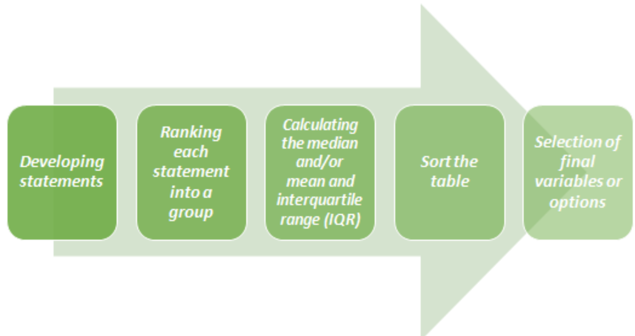

Fig. 2. Final questions

Second stage - to administer the Thurstone scale question and perform its analysis, fig.3.

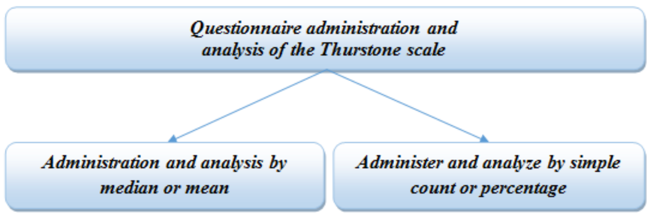

Fig.3. Question administration

Questionnaire administration and analysis of the Thurstone scale

Once the final questions are selected, they are shared with respondents to select agreement or disagreement. Ratings are shown in parentheses, but the rating is not shared with actual respondents .

- **Administration and Analysis by Median or Mean:** The question and subsequent options can be administered to respondents by using the median or mean score in the form below. The assertion weights are summed and divided by the number of verified assertions. If the respondent agrees with statements 2, 5, 7 and 10; the ratio score is 10.5 + 2.5 + 4.5 + 6.0 = 23.5/4 = **5.8** . Dividing the number of statements puts this score just above the midpoint of the 1-11 scale. This result indicates that the attitude is slightly favorable towards hiring people with diversity in the organization.
- **Administration and analysis by simple count or percentage:** In the same example above, if the question is administered without a mean or median score, the calculation can be represented by a simple count of agreement on a 1-11 scale or percentage. If the respondent agrees with statements 1, 4, 5, 6, 8, 9 and 11; the number of agreements is 7 out of 11, which puts the percentage at 63.63%, which means that the attitude is favorable to hiring with diversity.

1.3. Thurstone scale question characteristics

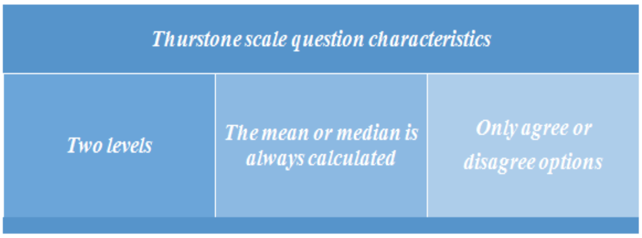

Fig.4. Thurstone scale question characteristics

Some distinguishing features of the Thurstone scale question are:

- **They are two-step:** A Thurstone scale question is never administered in the first iteration stage without a judge rating.
- **The mean or median is always calculated:** Since each option is weighted, the mean or median is calculated for each option.
- **Agree or Disagree Options Only:** The respondent makes a choice based only on agreeing or disagreeing with the statement.[10]

1.4.Advantages and disadvantages of the Thurstone scale

ADVANTAGES	DISADVANTAGES
Allows a large number of statements to be written	It takes a lot of time
High reliability of the survey	Complex scale – requires a lot of time and resources
It represents an average result that is easy to compare	Limited response options

Fig.5. Advantages and disadvantages, [9]

2.Guttman scale, which was proposed by the American sociologist of Russian origin Louis Guttman (Louis Guttman, 1916-1987) in 1950. It allows a measurement to be made through a set of judgments with varying degrees of intensity, with which the respondent agrees or disagrees. For example, if the researcher wishes to measure discrimination against the Roma with the Gutman scale, the following questions can be asked: (a) Should the Roma be allowed to live in the same neighborhoods as the Bulgarians? (b) Would you agree if your neighbor was Roma? (c) Can rum be your close friend? (d) Would you marry a rum? The answers to the questions are binary (two): (1) Agree and (2) Disagree.[2]

2.1.Definition of the Guttman scale

The Guttman scale is one of the three one-dimensional scales, the other two being the Likert scale and the Thurstone scale . The Guttman scale, also called cumulative scaling or scalogram analysis , is created with items that can eventually be ordered in a hierarchical fashion. It is representative of the exceptional "attitude" of the respondents, i.e. extremely positive or negative, about the object under consideration.

This scale is used by researchers in situations where a unidimensional scale for a continuum of opinions is needed. A 'unidimensional' scale indicates that the response options have only one parameter to measure, ie. a range of numbers can be associated with the scale. For example, "On a scale of 0 to 10, how satisfied are you with the service of this airline?" - can be indicated with one-dimensional response options.

The Guttman scale has a list of statements. It can be concluded that respondents who agree with the statement placed at the end of this list would agree with all the other statements above the last one. Each statement will have a corresponding weight attached to it. The weighting of respondents feedback will help researchers predict the number of statements that are acceptable to respondents. For example, on a Gutman scale of 5, if a respondent gets a 3 - it means that he/she agrees with the first 3 statements of the scale, if another respondent gets a 5 - it means that he/she agrees with all the statements in this cumulative scale.

The main purpose of this scale is to filter out those respondents who answer 100% of the statements indicated in the scale. But in practice, it is very unlikely that respondents will fully agree with a set of statements, and thus a scalogram analysis is conducted to estimate the closest set of statements that the target audience agrees with. The Bogardus scale is a popular example of the Guttmann scale.

2.2. Features of the Guttman scale

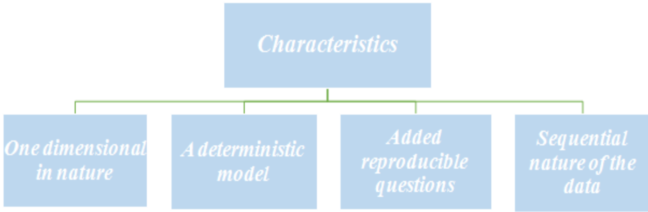

Fig. 6. The Guttmann scale

- **Unidimensional in nature:** The Guttman scale has statements in order of difficulty, from least difficult to most difficult, and is therefore unidirectional in nature. In Gutman's 10-item scale, if the respondent gets a score of 8 - this is indicative of the fact that the respondent agrees with the first 8 statements of the scale and disagrees with the last two statements of the scale.
- **Deterministic model:** Responses are considered according to the last agreed-upon statement from the scale and are cumulative of the responses.
- **Reproducible questions added :** The Guttman scale only has questions that are reproducible , meaning that those questions that will not be able to produce the desired results will be eliminated from the scale and only those questions that can increase the target will be included of scalability .
- **Ordinal nature of data:** The list of statements is ordered in an ordinal manner ie. from the least important statement to the most important statement.

2.3. Steps for developing a Guttman scale

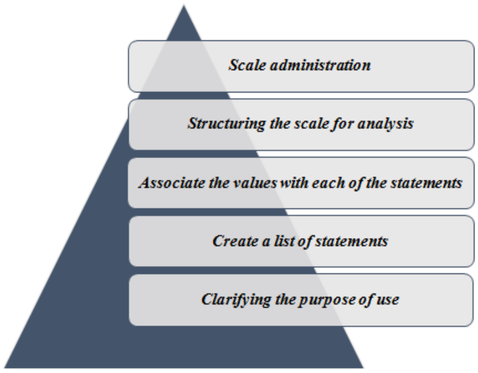

Fig.7. The Guttmann scale

- **Clarifying the purpose of using the Guttman scale:** Any scaling method must have a clearly defined purpose for effective application.
- **Creating a list of statements:** To get the desired insight into the development of laws, the responsible persons can create a list of statements for the scale or involve specialists so that effective statements can be included in the scale.
- **Assign values to each of the statements:** Experts involved in the statement development process should assign values to each of the statements according to their importance to the topic

of school shooting laws. Experts are expected to answer Yes if the statement is in favor of laws against school shootings and No if the statement is not in favor of laws against school shootings.

- **Structuring the Guttman scale for analysis:** Guttman scale analysis is the most important step. The answers obtained for different statements can be presented in a matrix.

Table 1. Structuring the Guttman scale for analysis

RESPONDENT	STATEMENT 1	STATEMENT 2	STATEMENT 3	STATEMENT 4	STATEMENT 5
5	yes	yes	yes	yes	yes
10	yes	yes	yes	yes	-
15	yes	yes	yes	-	-
16	yes	-	-	yes	-
20	yes	yes	-	-	-
21	-	-	--	-	-

In the above matrix in the first row, if someone agrees with statement 5, it means that the person must have agreed with the previous statements, ie. – statement 1 to statement 4.
Also, there may be exceptions in respondents answers, but generally those respondents who agree with statement 4 would agree with statements 1 to statement 3.

- **Administration of the scale:** After deciding on the various items (statements) of the scale, it is time to administer the responses obtained for each of the items. Respondents need only indicate their agreement with each statement.

2.4.Advantages and disadvantages of the Guttman scale.

Table 2. Advantages and disadvantages,[10]

ADVANTAGES	DISADVANTAGES
Highly hierarchical and structured in nature	Difficult to construct
Implemented to gain insight into multiple queries	The analysis may be too restrictive
Creates data in a ranked manner	The rank order of the statements may not be interpreted in the same way

3. Likert scale

The scale was proposed by the American social psychologist Rensis Likert (Rensis Likert, 1903-1981) in 1932. It measures the strength with which the respondent agrees or disagrees with a given statement, and for this purpose makes a gradation of the degrees of agreement or disagreement with the statement. Unlike the Thurston and Guttman scales, the Likert scale answers are not binary (two), but a different number.[2]

3.1. What is a Likert scale?

A Likert scale question is a psychometric scale where questions based on this scale are used in a survey. This is one of the most widely used types of questions in a survey. In a Likert scale survey, respondents do not choose between yes/no, there are specific choices based on 'agree' or 'disagree' on a particular survey question.
To understand the Likert rating scale, one must first know what a survey scale is.
scale is a set of response options-numerical or verbal-that capture a range of opinions on a given topic. It is always part of a closed question (a question that provides respondents with pre-filled response options).
Likert scale survey question ? This is a question that uses a 5, 7, or 10-point scale, sometimes called a satisfaction scale, that ranges from one extreme attitude to another. Typically, a Likert survey question includes a moderate or neutral option on its scale.
Likert scales are quite popular because they are one of the most reliable ways to measure opinions, perceptions and behaviour.
Compared to binary questions, which give only two answer options, Likert-type questions will give more detailed feedback on whether the product is just "good enough" or "excellent". And Likert questions can help decide whether a company's products or services have left customers feeling "very satisfied," "somewhat dissatisfied," or perhaps just neutral.
This method will reveal degrees of opinion that could make a real difference in understanding the feedback that is being received. It can also indicate areas where services or products can be improved.[12]

A Likert scale (typically) provides five possible responses to a statement or question that allow respondents to indicate their positive to negative strength of agreement or strength of feeling about the question or statement.

Table 3.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
(1)	(2)	(3)	(4)	(5)

The Likert scale assumes that the strength/intensity of the attitude is linear, ie. from strongly agree to strongly disagree, and makes the assumption that attitude can be measured.
For example, each of the five (seven or ten) responses will have a numerical value that will be used to measure the attitude under study.[13]

3.2. Advantages and disadvantages of Likert scales

Table 4. Advantages and disadvantages

ADVANTAGES	DISADVANTAGES
Easy to use	Two respondents can get the same values
Easy to report	Respondents tend to agree with the statements
Possibility of a neutral response	It is difficult to analyze neutral opinions
A time-saving method	

4. Comparison of the three methods

Table 5. Comparison of the three methods

Thurstone	Guttman	Likert
Allows a large number of statements to be written	Highly hierarchical and structured in nature	Easy to use
High reliability of the study	Implemented to gain insight into multiple queries	Easy to report
It represents an average result that is easy to compare	Creates data in a ranked manner	Possibility of a neutral answer
		A time-saving method

Thurstone	Guttman	Likert
It takes a lot of time	Difficult to construct	The same values can be obtained from two respondents
Complex scale – requires a lot of time and resources	The analysis may be too restrictive	Respondents tend to agree with the statements
Limited response options	The rank order of the statements may not be interpreted in the same way	Neutral opinions are difficult to analyze

CONCLUSION

From the information presented above, it can be concluded that the Thurston and Gutman scales require a lot of time and resources both for the compilation of the survey itself and for its analysis. Respondents may be confused by the response options provided. The scales are limited because the corresponding values are distributed according to the understanding of the experts on the one hand, and on the other hand the same data can be interpreted differently. This can lead to an error, and from there to an incorrect reading of the results of the conducted inquiry.

The disadvantages of the Likert scale are negligible compared to the other two scales. Here, the final result can be assumed to be closer to the real sentiments of the respondents .

Analyzing the positive sides of all scales, it can be noted that the Likert scale is much easier to compile and much better accepted among the respondents. The data that can be extracted through it is processed faster and points to real sentiments.

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Extended research on the efficiency of internal crystallization chemical admixtures for cement concrete - mechanical and structural characteristics

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Abstract: *In recent years, the use of internal crystallization chemical admixtures for concrete and mortar to increase their water-tightness and other physical and mechanical characteristics has been of increasing importance in modern construction. These types of chemical modifiers allow for the effective replacement of conventionally performed waterproofing works (membranes, rolls, brushed or sprayed coatings, etc.) by purposefully improving the physical-mechanical characteristics of structural concretes, rendering them, to one degree or another, impermeable to water or/and aggressive agents from different origins. In the specialized world market for such products there are several leading competing companies - producers of internal-crystallization chemical admixtures, which have different activity in Bulgaria.*
The new extended research on such several new types of those admixtures were reported and discussed. The complex mechanical and structural tests are conducted and respective results are compared to predict the admixture's efficiency of their ability to limit the ingress of water into concrete and reinforced concrete sections, as well as their ability to increase the durability of concrete as the main structural material.
Keywords*: PORTLAND CEMENT CONCRETE AND MORTAR, INTERNAL CRYSTALLIZATION CHEMICAL ADMIXTURES, CONCRETE WATERPROOFING, DTA, SEM, BET STRUCTURAL INVESTIGATIONS*

1. Introduction

In recent years, the use of internal crystallization chemical admixtures for concrete and mortar to increase their water-tightness and other physical and mechanical characteristics has been of increasing importance in modern construction. These types of chemical modifiers allow for the effective replacement of conventionally performed waterproofing works (membranes, rolls, brushed or sprayed coatings, etc.) by purposefully improving the physical-mechanical characteristics of structural concretes, rendering them, to one degree or another, impermeable to water or/and aggressive agents from different origins [1].

In the specialized world market for such products there are several leading competing companies-producers of internal-crystallization chemical admixtures, which have different activity in Bulgaria.

Since 2017 and at the moment, a part of the author's scientific interests are directed towards conducting specialized research for the comprehensive characterization of many such admixtures, more or less known on the Bulgarian market.

The admixtures, previously tested and compared are KRYSTALINE Add1, KRYSTALINE Plus 2.5, PENETRON Admix, XYPEX C1000 NF and BETOCRETE-CP-360-WP [2,3].

The present research is devoted to full-range testing and comparing of couple of different crystallization admixtures - KRYSTALINE Add1, Krystol Internal Membrane (KIM®), SIKA WT-200P, MAPEI Indrocrete KR1000 and ADING Hydrofob Crystal.

The purpose of the investigation is to assist all participants in the construction investment process in understanding the nature, specific characteristics and differences in the performance (effectiveness) of different products in terms of their ability to limit the ingress of water into concrete and reinforced concrete sections, as well as their ability to increase the durability of concrete as a main structural material.

2. Tests methods and comparative characteristics

The tests method used and all comparative characteristics are equal to previous already published ones [2,3]. The mix design of ordinary reference concrete (Table 1) was used to perform the studies, with the mineral composition of the cement being presented in Table 2.

For the purpose of comparative studies to the mix of reference concrete (Table 1), the appropriate crystallization chemical admixtures are incorporated in the dosage and according to the technology prescribed by their manufacturer.

The homogenization of the fresh concrete is accomplished by adding a metered amount of mixing water to obtain the same workability as assessed by the slump measure. The chosen method of comparison on the basis of **"equal workability"** of the concrete mixture is directly related to the actual production conditions at the construction site, where the **"workability"** factor is the key one to the quality of the concrete works performance.

The following physical-mechanical and structural characteristics have been selected to compare the same age of the fresh concrete and the hardened concrete:

- **fresh concrete** - water-cement ratio, consistency by slump test (cm), change of consistency in time after homogenization, air content (%);
- **hardened concrete** - compressive strength (MPa), splitting tensile strength (MPa), the static modulus of elasticity deformation (GPa), the depth of penetration of water under pressure (mm), frost resistance under an accelerated method (loss of mass change and the speed of ultrasound propagation) - cycles, structural studies (low-temperature gas absorption (BET method), differential thermal analysis (DTA), X-ray phase analysis (RFA) and scanning electron microscopy (SEM);
- **cement-sand mortar** - capillary absorption.

Table 1*: Concrete mix design.*

№	Materials	Quantity, kg/m^3
1.	Portland cement CEM II 42,5 A-LL, Devnya Cement Plant, Bulgaria	330
2.	River sand, fraction 0-4 mm, Quarry "Chepinzi"	810
3.	Crushed stone, fraction 4-11,2 mm, Quarry "Studena"	1060
4.	Mixing water for fresh concrete slump 13 cm (S3)	≈250 (for reference concrete)

Table 2 *Mineral composition of the Portland cement used*

Cement type	Specific surface, cm^2/g	Mineral composition, % by mass			
		C_3A	C_3S	C_2S	C_4AF
CEM II 42,5 / A-LL	3620	9,40	55,50	24,60	10,50

3. Description of crystallization admixtures tested

The description and basic peculiarities of the admixtures tested is given in Table 3. Their dosage rates are in accordance of the respective manufacturers.

KRYSTALINE Add1 has the advantage of being dosed in all cases in constant quantities (1,0 kg/m^3) regardless of the concrete formulation of the concrete. The only requirement is cement content above 300 kg/m^3.

Krystol Internal Membrane (KIM®), SIKA WT-200P, MAPEI Indrocrete KR1000 and ADING Hydrofob Crystal are dosed depending on the type and amount of cement used in the concrete mix design, which determines the need for specific calculations and non-constant costs in different projects.

Table 3 *Product description and dosage rates*

Product	Description	Dosage rates (accordance producer's recommend-dations)
KRYSTALINE Add1 Krystaline Technologies SA, Spain	Crystallizing waterproofing admixture with catalytic action to increase the water resistance and durability of concrete. Slightly slows down the concrete setting and hardening times and decreases exothermic. Self-healing cracks up to 0.5 mm wide.	1,00 kg/m^3 (permanent, regardless of the cement content)
Krystol Internal Membrane (KIM®)	Krystol Internal Membrane (KIM®) is a chemical admixture in dry powdered form, effective in creating waterproof concrete. It enhances the hydration process by intensifying and prolonging the hydration of the cementitious materials in concrete. The admixture delays the setting time of concrete. Self-healing cracks up to 0,5 mm wide.	6,60 kg/m^3 (2% by weight of cement, max 8 kg/m^3 concrete)
SIKA WT-200P, SIKA Limited, U.K.	SIKA WT-200P consists of mixture of cements, amino alcohols and fillers to increase the water resistance and concrete durability. Some specific conditions can affect the setting time. Self-healing cracks enhancement.	3,50 kg/m^3 (for concrete with min cement content 350 kg/m^3 and max water-cement ratio 0,45)
MAPEI Indrocrete KR1000, Italy	Indrocrete KR1000 is a mixture of active components which, in presence of water, transform the by-products of cement hydration into crystals reducing concrete porosity and micro-cracks. Self-healing cracks up to 0,4 mm wide.	6,6 kg/m^3 (1-3 kg/100 kg cementitious materials)
ADING Hydrofob Crystal, North Macedonia	Crystallizing waterproofing admixture with hydrophobic effect. Self-healing – no data available.	3,50 kg/m^3 (3-4 kg/m^3 concrete, min compressive class C25/30)

4. Results and discussion

The focus of this paper is to emphasize the significant differences in respective mechanical and micro-structural characteristics at 28-days of age. The first range of testing are performed in accordance of all respective Bulgarian and EN standards. The second one - by using of advanced direct physics methods - low-temperature gas absorption (BET method), differential thermal analysis (DTA), X-ray phase analysis (RFA) and scanning electron microscopy (SEM).

4.1. Mechanical tests

All results are presented in Table 4. The characteristics of the hardened concrete with equal workability of the fresh concrete show significant advantages of crystallization admixtures KRYSTALINE Add1 over Krystol Internal Membrane (KIM®), SIKA WT-200P, Indrocrete KR1000 and Hydrofob Crystal - compressive, tensile splitting strength and modulus of elastic deformation increasing, a reduced depth of water penetration under pressure and significantly higher frost resistance.

Table 4 *Mechanical characteristics*

CHARAC-TERISTICS	COMPOSITIONS TESTED (at equal workability)					
	Ref. concrete without admixture	KRYS-TALINE Add1 1,0 kg/m^3	KIM®, Kryton 6,6 kg/m^3	SIKA WT–200 P 3,5 kg/m^3	Indrocrete 6,6 kg/m^3	Hydro-fob Crystal 3,5kg/m^3
Volume density (mean), kg/m^3	2330	2320	2330	2320	2330	2310
Compressive strength, (mean), MPa	27,30	38,10	32,00	32,30	32,70	30,80
compared to reference concrete, %	0	+39,56	+17,21	+18,32	+9,78	+12,82
Tensile splitting strength, (mean), MPa	2,28	2,78	2,69	2,61	2,71	2,58
Compared to reference concrete, %	0	+21,93	+17,98	+14,47	+18,96	+13,16
Static elastic modulus,GPa	27,6	30,1	29,0	29,1	29,4	28,3
compared to reference concrete, %	0	+9,1	+4,7	+5,4	+6,1	+2,2
Depth of water penetration under pressure, mm	36	10	20	21	16	17
compared to reference concrete, %	0	-360	-180	-171	-225	-212
Freeze-thaw resistance, weight lost up to 2%: - %, after 2 cycles, (C_{frost} 75); - %, after 3 cycles (C_{frost}100); - %, after 4 cycles (C_{frost}150); - %, after 5 cycles (C_{frost}200)	1,82 (passed) 2,5	0,42 (passed) 0,92 (passed) 1,79 (passed) 2,03	1,03 (passed) 1,60 (passed) 2,13	1,08 (passed) 1,56 (passed) 2,19	0,77 (passed) 1,13 (passed) 2,04	1,03 (passed) 1,94 (passed) 2,46

4.2. Low temperature gas absorption (BET- method)

Gas adsorption is a modern method of characterizing porous materials. In the case of physical gas adsorption, inert gas (most commonly nitrogen) is adsorbed on the surface of a solid material. Based on the amount of adsorbed gas and the corresponding gas pressure, so-called an Arizona thermal adsorption curve from which basic parameters of the pore structure of materials can be determined.

The results are presented in Table 5 and Figures 1-6.

Table 5 *Micro-pore structure characteristics*

CONCRETE TESTED	STRUCTURE CHARACTERISTICS		
	Specific surface of pore structure, S_{BET}, m^2/g	**Total pore volume, Vt, cm^3/g**	**Pore size distribution by diameter, D_{av}, nm**
Reference concrete – without admixture	61	0,13	8,8
KRYSTALINE Add1	35	0,07	7,5
Krystol Internal Membrane (KIM®)	44	0,09	8,3
SIKA WT-200P	50	0,11	9,1
MAPEI Indrocrete KR1000	55	0,09	6,3
ADING Hydrofob Crystal	54	0,10	7,4

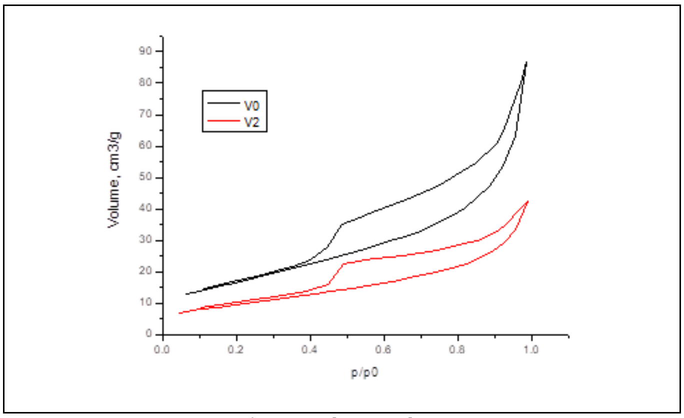

Fig. 1 *Total pore volume -*
Reference concrete (V0) vs. KRYSTALINE Add1 (V2)

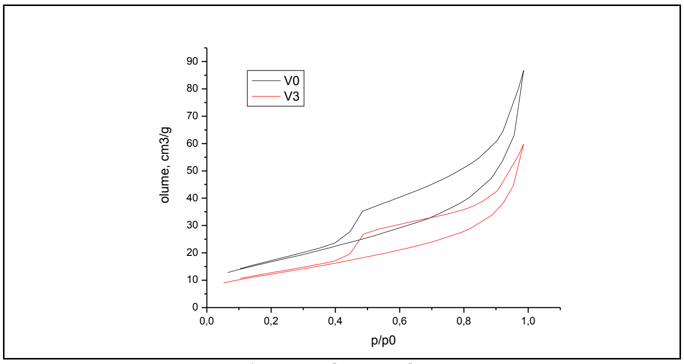

Fig. 2 *Total pore volume -*
Reference concrete (V0) vs. Krystol Internal Membrane (KIM®) *(V3)*

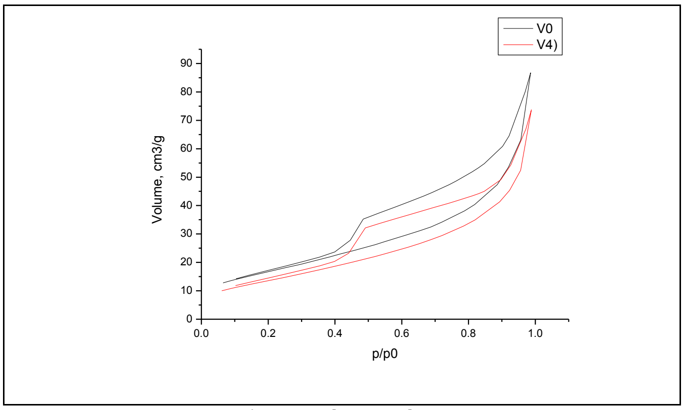

Fig. 3 *Total pore volume -*
Reference concrete (V0) vs. SIKA WT – 200P (V4)

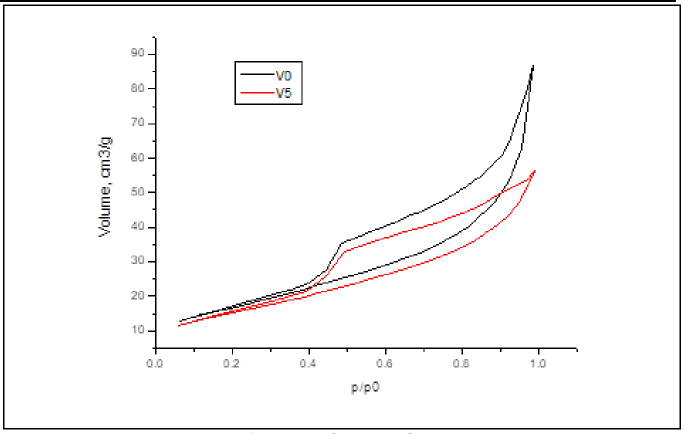

Fig. 4 *Total pore volume -*
Reference concrete (V0) vs. MAPEI Indrocrete (V5)

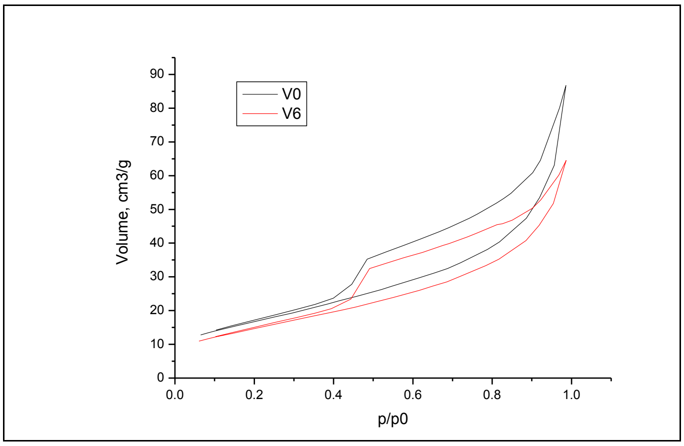

Fig. 5 *Total pore volume -*
Reference concrete (V0) vs Hydrofob Crystal (V6)

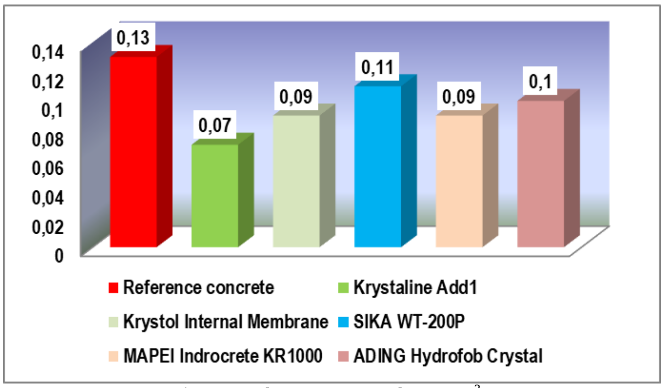

Fig. 6 *Total micro-pore volume, cm^3/g*

With the same workability of the fresh concrete, the crystallization admixture KRYSTALINE Add1 form a fine-dispersed cement stone structure in the concrete with a significantly reduced total micro pore volume, compared to the concrete with the participation of Krystol Internal Membrane (KIM®), SIKA WT-200P, Indrocrete KR1000 and Hydrofob Crystal.

4.2. Differential-thermal analysis (DTA)

The results are presented in Table 6 and Figures 7-12.

Differential thermal analysis (DTA) is a method that belongs to the set of direct physical methods for the study of crystalline structure in silicate composites. It is based on the characteristic feature of the hydrated formations in the cement stone to dehydrate in a precisely defined temperature range. The corresponding dehydration is accompanied by a characteristic thermal effect that alters the heat balance of the system. The monitoring of the respective endo- and exo-effects allows one to judge the phase transformations identified by the release of chemically bound water. Knowing the reference for the individual silicate formations and temperatures of the phase transition, one can directly judge the presence and the indicative amount of the corresponding compound.

Table 6 *Structure characteristics*

CONCRETE TESTED	**BASIC STRUCTURE COMPOSITIONS**	
	Portlandite $Ca(OH)_2$, rel.%	**Crystals C-S-H, Calcite $CaCO_3$, rel.%**
Reference concrete (K "0") without admixture	2,311	9,108
KRYSTALINE Add1	1,600	11,089
Krystol Internal Membrane (KIM®)	1,939	9,866
SIKA WT-200P	2,183	9,391
MAPEI Indrocrete KR1000	2,016	10,953
ADING Hydrofob Crystal	2,238	9,403

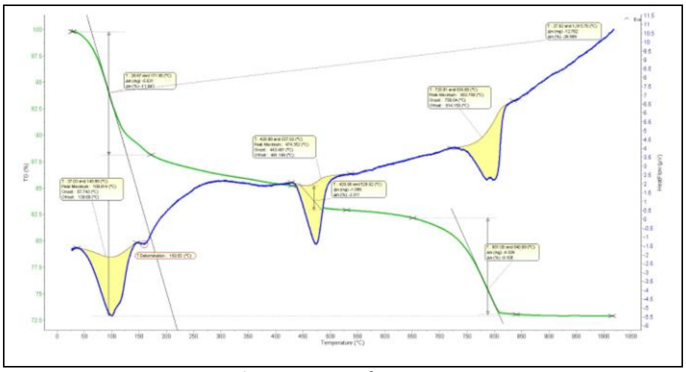

Fig. *7 DTA - Reference concrete*

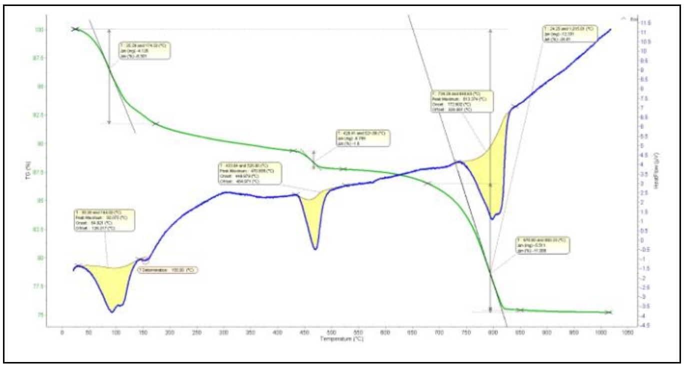

Fig. 8 *DTA - KRYSTALINE Add1*

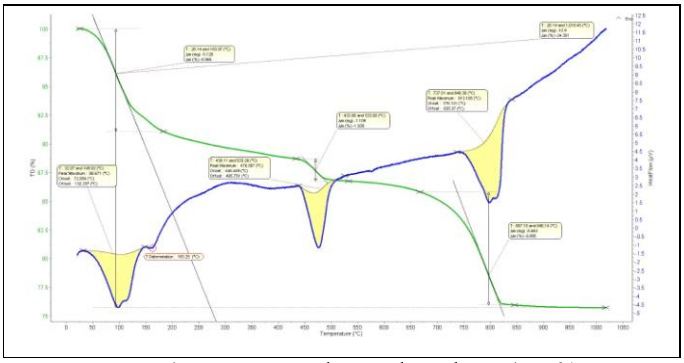

Fig. 9 *DTA- Krystol Internal Membrane (KIM®)*

With the same workability of the fresh concrete, the crystallization admixtures KRYSTALINE Add1 form a waterproof crystalline structure with a predominant involvement of CSH-type high-alkalinity hydrate formations (main carriers of high mechanical properties of the composite), compared to concrete with Krystol Internal Membrane (KIM®), SIKA WT-200P, Indrocrete KR1000 and Hydrofob Crystal.

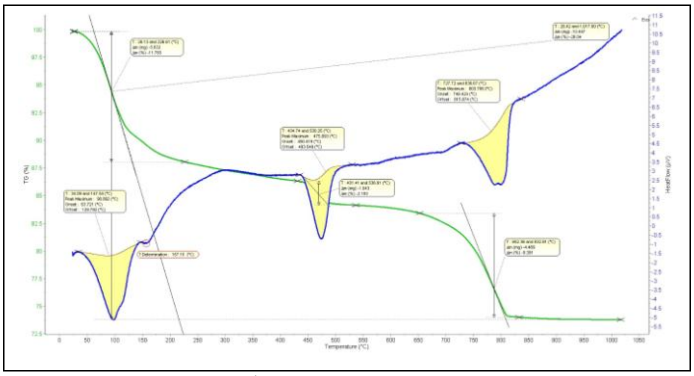

Fig. 10 *DTA - SIKA WT-200P*

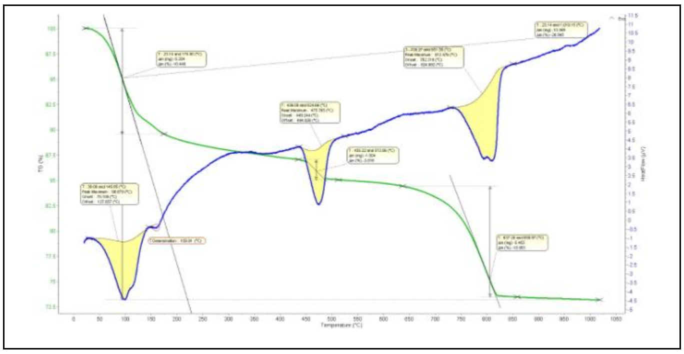

Fig.11 *DTA - MAPEI Indrocrete KR1000*

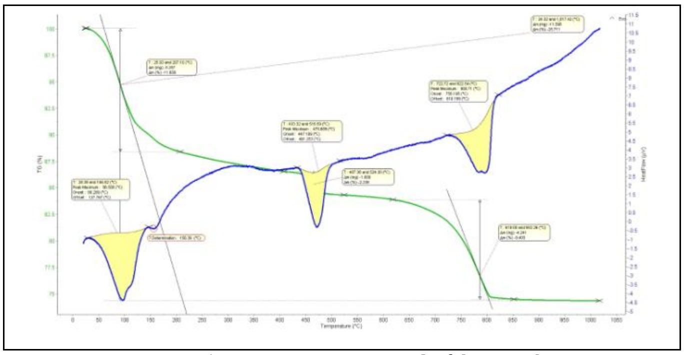

Fig. 12 *DTA - ADING Hydrofob Crystal*

4.3. Scanning Electron Microscopy (SEM)

The results are presented in Photos 1-6.

Scanning electron microscopy (SEM) is performed using a high magnification electron microscope (up to 10,000 times), resulting in visual data on the shape and size of individual sub-microscopic crystals, their growth, decomposition and destruction processes, and this base passed is sued for past chemical interactions in solution and solid phase, incl. to seal the structure.

In support of the demonstrated significant advantages with respect to the basic physics-mechanical properties of the crystallization additive KRYSTALINE Add1 over Krystol Internal Membrane (KIM®), SIKA WT-200P, Indrocrete KR1000 and Hydrofob Crystal, are the results obtained by using modern direct physics-chemical methods. They show that the concrete with KRYSTALINE Add1 form a denser waterproof crystalline structure with a dominant participation of high-alkalinity C-S-H hydrate formations, bearing high mechanical performance of the composite.

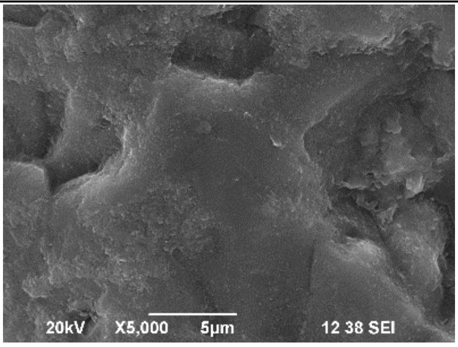

Photo 1 *Reference concrete*

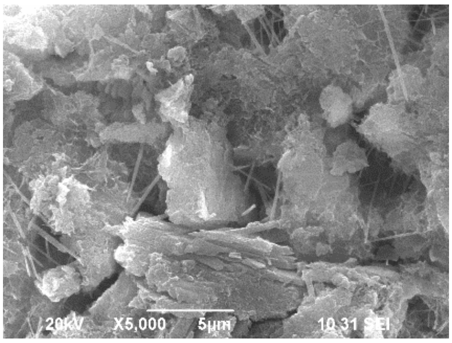

Photo 2 *KRYSTALINE Add1*

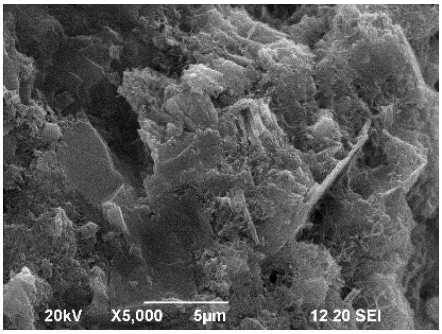

Photo 3 *Krystol Internal Membrane (KIM®)*

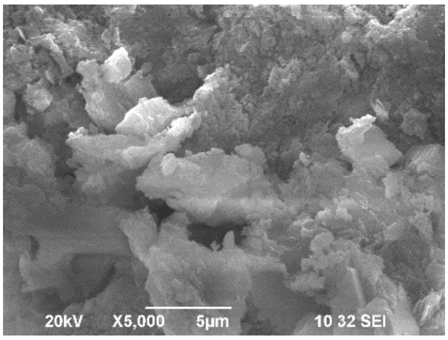

Photo 4 *SIKA WT-200P*

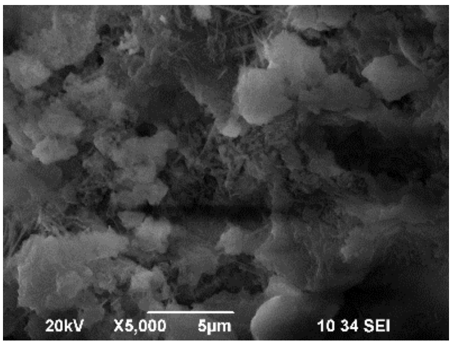

Photo 5 *MAPEI Indrocrete KR1000*

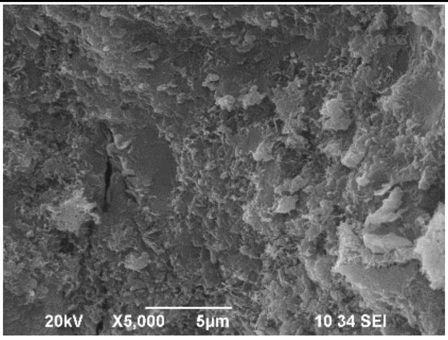

Photo 6 *ADING Hydrofob Crystal*

5.Conclusions

The above comprehensive comparative analysis for the evaluation of the basic physical-mechanical and structural characteristics of the fresh and hardened concrete with 5 types of internal crystallization chemical admixtures entering the Bulgarian construction market, objectively presents the characteristics of the compared products.

In accordance with the stated goal, this report is able to assist the participants in the investment construction process (investors, designers, contractors, project managers and supervisors), in situation of an informed choice, to evaluate the complex advantages of KRYSTALINE Add1 vs. Krystol Internal Membrane (KIM®), SIKA WT-200P, Indrocrete KR1000 and Hydrofob Crystal.

Concretes with the participation of KRYSTALINE Add1 (with a constant dosage rate of 1,0 kg/m^3), ensure the impermeability and safe water-tightness of the concrete cross section, even under water pressure, without the need for additional waterproofing activities of various types - brushed and sprayed coatings, coiled and membrane conventional systems. At the same time, such concrete has increased frost-resistance and durability without the need for accompanying repair and restoration work.

By all tested parameters, concrete with KRYSTALINE Add1 outperformed with Krystol Internal Membrane (KIM®), SIKA WT-200P, Indrocrete KR1000 and Hydrofob Crystal.

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Stress and stability calculation of the third pass module of the steam boiler during lifting

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Abstract: *This paper presents the calculation of the stress and stability of a third-cycle module of a steam boiler during the lifting process. A steam boiler is a key element of a cogeneration plant, so all calculations are performed according to prescribed standards. Before the numerical analysis of the steam boiler, the characteristics, components and function of the boiler are described, as well as the required standards. The 3D model of the boiler was created using the Abaqus/CAE 2016 program package according to the manufacturer's technical documentation. Using the finite element method, the stresses and stability during lifting of the boiler from the horizontal and vertical positions were calculated and presented. It was found that when lifting from a horizontal position, the structural stress values of the main elements do not exceed the allowable values. On the other hand, when lifting from a vertical position, the stresses exceed the allowable values. In this case, the connection point between the lug and the profile was checked and analytically dimensioned. The obtained values of the stability analysis of the boiler module are satisfactorily defined and there is no risk of buckling in both cases of lifting. The boiler conforms with the standard and fulfils the requirements handed over to the engineer.*
Keywords*: STEAM BOILER, STRESS, STABILITY, FINITE ELEMENT METHOD*

1. Introduction

In a conventional context, a steam boiler is a closed vessel and it allows the transfer of combustion heat to the working medium until it is boiling and becomes steam. It could be stated that a steam boiler is an exchanger of heat between water and fire. It is the part of a steam generated power plant process that and as a result produces the heat. That generated steam can then be utilized to pass the heat to a process that and transforms it to work [1].

The main components of a cogeneration plant are: Steam Boiler, Steam Turbine and Electricity Generator. Fuel and air are supplied to the steam boiler to produce high pressure steam through the combustion process. The high-pressure steam is fed into the steam turbine, where the expansion of the steam converts some of the heat energy into mechanical energy of rotor rotation. The rotor of the electric generator is attached to the steam turbine rotor, and the mechanical energy is converted into electricity. Depending on the needs, the steam exiting the turbine is used for technological processes or for heating. If the thermal energy of the output steam is not fully used, it is directed to the condenser and released to the ambient air or water. The energy efficiency of this type of equipment ranges from 0,7 to 0,8 [2].

A cogeneration plant that uses biomass as a fuel source becomes more environmentally friendly by using waste materials from the wood industry and more competitive in the marketplace by having a more acceptable price and locally available fuel sourcing [3-7]. In the following chapters, the characteristics, components, and functions of combined heat and power plants and steam boilers are described in more detail. The calculation of the stresses and stability of the module of the third pass of the steam boiler during lifting is performed using the Abaqus/CAE 2016 program package. The cases of lifting from the horizontal and vertical position are considered, all stages of the analysis are described in detail. It is essential for a designer to engineer and calculate a steam boiler that provides security, durability and usability to the customer. Completing that task requires a great understanding of the design specifications, especially geometry of the pressure vessel, which has to be reviewed to abide with the standards for the design [8]. For that reason, various studies have been conducted and performed to describe the design and calculations of steam boilers [9-12].

This paper presents the results of the stress and stability calculation of the third pass module of the boiler during the lift. The 3D model of the steam boiler was designed using the Abaqus/CAE 2016 program package [13] based on the technical documentation of company Đuro Đaković Termoenergetska Postrojenja d.o.o. [14]. Using the finite element method, the stresses and stability in the course of lifting the boiler from the horizontal and vertical positions were calculated and described.

2. Problem description

The lifting and positioning of the boiler to a certain height is done with an overhead crane using trusses, pulleys and ropes. A truck with a trailer is positioned under the lifted boiler, which is lowered onto the trailer and transported to the cogeneration plant construction site. The process is shown in Figure 1.

Fig. 1 *Steam boiler module transport*

At the construction site, the boiler module must be lifted from the trailer and installed in a supporting steel structure (Figure 2). The boiler is lifted by two cranes, and its rotation is performed in the air. The supporting steel structure is a spatial metal structure used for fastening, supporting and suspending heating surfaces, walls, smoke ducts, piping and other elements belonging to the boiler. Due to significant thermal expansions, the structure is a very responsible part of the boiler. The design of the steel structure depends on the steam boiler, because the design solutions of boilers can be very different.

Fig. 2 Supporting steel structure

The steel support structure consists of the main columns mounted on concrete foundations and steel feet. The main columns are connected by cross beams, and the areas between them are filled with auxiliary frames and struts. They are most commonly used for supporting brackets for studs and sheet metal boiler formwork. In this paper, two cases of lifting are considered: from a horizontal and a vertical position.

Lifting from a horizontal position is done in such a way that the first crane is connected to the first lifting beam, lifting beam 1 is attached with ropes to the auxiliary lifting beam, which is connected to lugs no. 1 and 2. The second crane is connected to the second lifting beam, two pulleys are connected to beam 2, a rope is passed through them and attached to lugs no. 3 and 5 and no. 4 and 6 respectively. In this way, the load is evenly distributed to all four lugs, as can be seen in Figure 3. The first and the second crane simultaneously lift the boiler module to the required height in relation to the trailer. After that, the first crane maintains the position reached, while the second crane continues its rotation to the final vertical position.

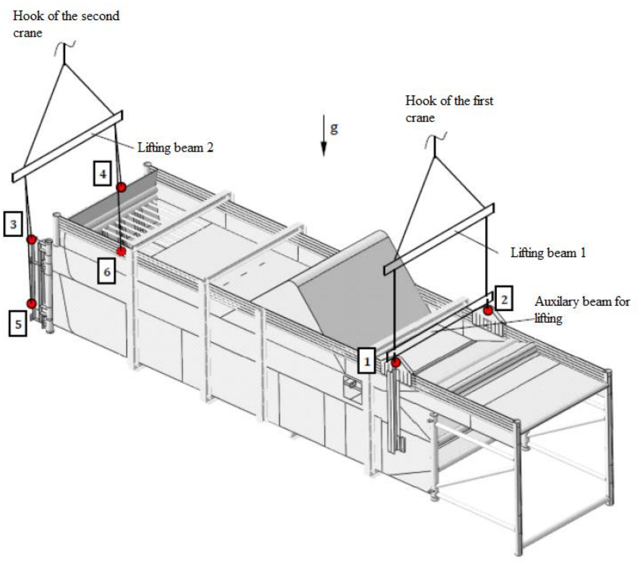

Fig. 3 The display of lifting the module from the horizontal position

After the boiler module is rotated to the vertical position, it is lifted and inserted into the supporting structure. Figure 4 shows the process of fixing the boiler module to the cranes, its lifting, rotation and insertion into the supporting steel structure.

Fig. 4 Attaching the boiler module to cranes, its lifting, rotation and placement in the load-bearing steel structure.

3. Numerical analysis of the boiler module

The boiler module is bounded by the back and side walls of the first, second, and third boiler passages. The 3D model shown in Figure 5 was created using Abaqus software [13]. The geometric model is discretized mainly with finite shell elements. Around the walls of the boiler module, there are bandages enclosed in a support ring, which help to stiffen the membrane walls (defined as an orthotropic plates) to maintain stability during lifting and placement of the module. Supporting profiles and bandages are defined by beam elements to which the required properties are assigned. The 3D model was created according to the technical documentation [14].

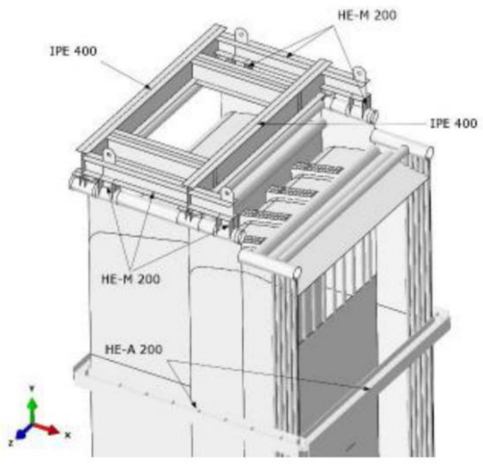

Fig. 5 Display of loading profiles and bandages

The numerical calculation of the boiler module is performed for the cases of lifting from horizontal and from vertical position. The first step is to create and define the properties of all materials used. The material 16Mo3 is applied to the side and rear walls of the passage, bandages, supporting profiles and chamber. The material S235JR+N / S355J2+N is defined for lugs and reinforcements, the yield strengths of the mentioned materials are defined by standards [15-17], as shown in Table 1.

***Table 1** Properties of defined materials [15-17]*

Material	Thickness, *t*, mm	Yield strength, $R_{p0,2}$, MPa	Norm
16Mo3	$t \leq 16$	280	EN 10216
	$16 < t \leq 40$	270	
16Mo3	$t \leq 16$	275	EN 10028-2
	$16 < t \leq 40$	270	
S235JR+N	$t \leq 16$	235	EN 10025-2
	$16 < t \leq 40$	225	
S355J2+N	$t \leq 16$	335	EN 10025-2
	$16 < t \leq 40$	345	

The membrane wall of a steam boiler can be approximated by an equivalent orthotropic plate that has the same elastic properties as a true membrane wall. Using Kirchhoff-Love shell theory, the constitutive equation of an equivalent orthotropic plate can be written:

$$\sigma = D \cdot \epsilon \tag{1}$$

Where σ is the vector of internal forces, D is the elasticity matrix, ε is the deformation vector. The matrix expression (1) represents the six constitutive equations of the membrane wall as a structurally orthotropic plate or an equivalent orthotropic plate, which connect the internal forces with the corresponding deformations. The next step of the numerical calculation is to define the stiffness matrix for each wall (back wall and side walls of the first, second and third pass).

To obtain the desired results, the model is assigned the material properties of the above-mentioned materials. For lifting from the horizontal position, a global model is created using a coarse mesh with a finite element mesh size of 40 mm, and an element size of 5 mm is specified at the locations of the structural elements that are important for the lifting conditions. Four boundary conditions are applied. The first boundary condition is located on lug no. 1, with restricted *x*-direction. The second boundary condition applies to the lug No. 2, with restricted *x*-direction. The third boundary condition is on lug no.3, with both the *x* and *y* directions constrained. The fourth boundary condition is applied to lug no. 4, with both the *x* and *y* directions constrained. For lifting from the vertical position, a global model is also created with a coarse mesh, but with a finite element mesh size of 50 mm. An element size of 5 mm is specified at the locations of the structural elements that are important for the lifting conditions. The same boundary conditions apply as for lifting from the horizontal position. Figure 6 shows the model with a fine mesh of the lug.

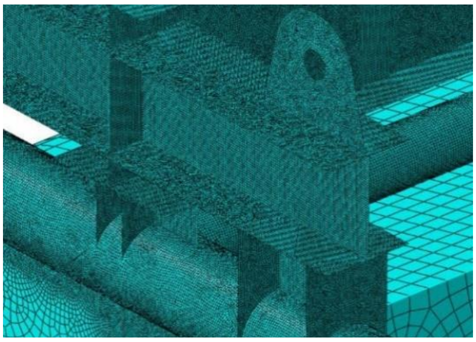

***Fig. 6** Model with fine mesh of the lug*

4. Results analysis

All material and test pressure data previously given were used to obtain results for lifting from horizontal and vertical positions. The stresses that occur at the top of the module when lifted from a horizontal position are shown in Figure 7. The maximum stress according to von Mises is 98 MPa.

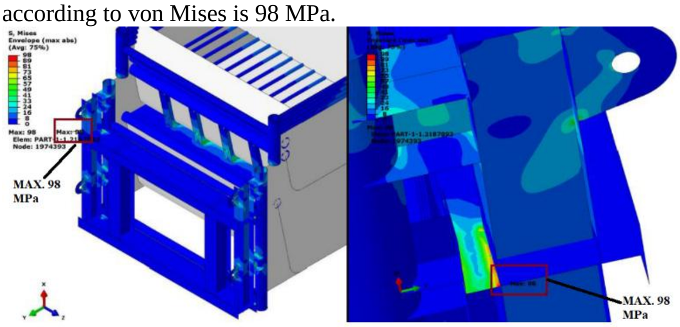

***Fig. 7** Distribution of the equivalent von Mises stress in conditions of lifting from a horizontal position*

The stresses occurring in the lower part of the boiler module are highest in the area of lugs 1 and 2, more precisely near lug 2, where the maximum stress according to von Mises is 125 MPa (Figure 8). The highest stress according to von Mises is at lugs 1 and 2, it is 43 MPa and is shown in Figure 9.

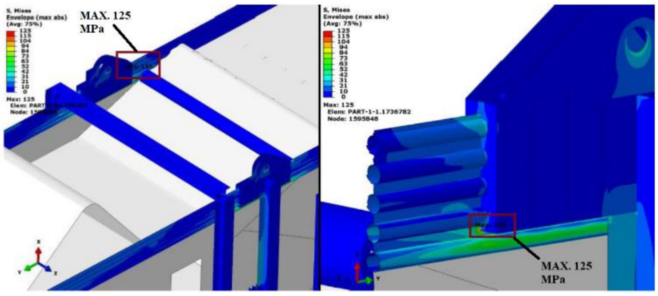

***Fig. 8** Distribution of the equivalent von Mises stress of the lower part of the module*

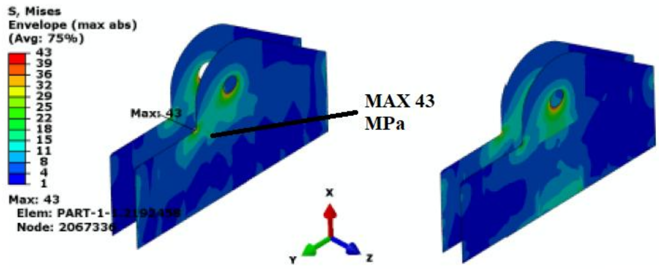

***Fig. 9** Distribution of the equivalent von Mises stress of the lugs 1 and 2*

The calculation of the stress on the structure in the conditions of lifting from a horizontal position was carried out under the load of its own weight. The yield strength of the lug material is $R_{p0,2}$ = 225 MPa [17], the safety factor is equal to S_F = 1,35 and the dynamic factor is equal to S_{din} = 1,2 [18]. According to the given data, the allowable stress is:

$$\sigma_{all} = \frac{R_{p0,2}}{S_F \cdot S_{din}} = \frac{225}{1{,}35 \cdot 1{,}2} = 138{,}8 \text{ MPa} \tag{2}$$

Since the maximum stress is 125 MPa, it does not exceed the allowable values, and it is not necessary to analytically check the joint between the lug and the profile HEM 200.

The stresses that occur on the upper part of the module when it is lifted from a vertical position are shown in Figure 10. The maximum stress according to von Mises is 217 MPa at the junction of the lug no. 6 and the profile HEM 200. The highest stress according to von Mises is at the lugs 1 and 2, it is 43 MPa and is shown in Figure 11.

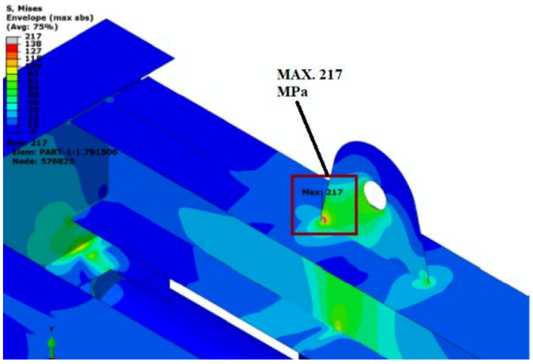

Fig. 10 *Distribution of the equivalent von Mises stress in conditions of lifting from a vertical position*

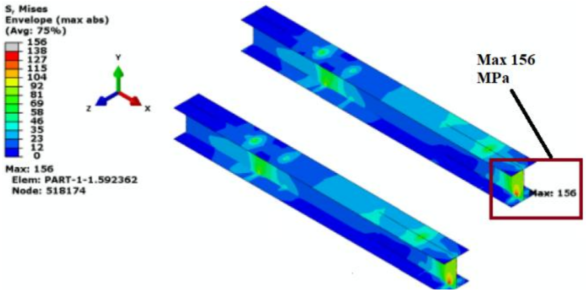

Fig. 11 *Distribution of the equivalent von Mises stress of the HEM profile*

The stress calculation of the structure under the conditions of lifting from a vertical position was carried out under the load of its own weight. Yield strength, safety factor and dynamic factor have the same values as in the case of lifting from a horizontal position. Since the highest stress occurs in the lugs, which are made of the same material, the allowable stress is equal to 138,8 MPa like in expression 2. Since the highest stress is 217 MPa, which exceeds the allowable values, it is necessary to check the connection point between the lug and the profile and dimension the lug. With this analytical calculation, the link plate, whose maximum stress is 105 MPa, is sized so that it does not exceed the allowable value and meets the prescribed condition.

4. Conclusions

This paper presents the results of stress and stability calculation of the third pass module of the steam boiler during the lift. The cases of lifting from a horizontal and vertical position are considered, and the work was carried out according to the technical documentation of the company ĐĐ TEP. In the work, the module is tested as described in the standard. Based on the obtained results of the numerical analysis, an analytical calculation of the lug was performed. The numerical analysis of the problem was performed using the Abaqus/CAE 2016 program package. The stress and stability results during lifting of the boiler module in two cases are presented.

It was found that when lifting from a horizontal position, the stress values of the structurally important elements do not exceed the allowable values and it is not necessary to analytically check the location of the connection of the lug and the profile. On the other hand, when lifting from a vertical position, the stresses occur in the upper part of the module, i.e. at the point of connection of lug no. 6 and the profile HE -M 200, exceed the permissible values. In this case, the position of the connection between the lug and the profile was checked and the required lug was analytically dimensioned. The boiler module conforms with the standard and fulfils the requirements handed over to the engineer in the construction of steam boilers.

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Analysis of the densification of a biomedical titanium alloy produced by powder metallurgy

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Abstract: *Titanium as a raw material for production is very expensive due to its high price and the complex production process. One of the successful alternatives for the production of titanium alloys and final products is powder metallurgy technology. In this work, a Ti-20Zr alloy for biomedical applications was produced using the powder metallurgy process. The density values determined for the compacts depend on the compression pressure. Namely, the compressibility of the powder mixture increases with increasing compaction pressure. A higher sintering temperature as well as a longer sintering time are more favourable to obtain higher values for the sintered density. Similarly, the compression coefficient is lower for samples compacted at higher pressure, while its value increases with increasing sintering temperature. The volume change in the volume of the sample is more pronounced after sintering at higher temperature and shorter time.*
Keywords*: TITANIUM-ZIRCONIUM ALLOY, POWDER METALURGY, MICROHARDNESS, BIOMEDICAL MATERIALS*

1. Introduction

Biomedical materials are usually used to replace lost or diseased biological structures in the human body and improve the quality of life. For this reason, this type of materials has received more and more attention in the last decades. The basic requirement that such materials must meet is good biocompatibility. The most widely used group of materials is metal biomaterials[1-6].

Titanium is the most important material for biomedicine thanks to its excellent corrosion resistance both in air and in biological fluids, as well as its good mechanical properties, including a good strength-to-weight ratio, and its ease of processing. Similarly, titanium favours osseointegration with the surrounding tissues, which favours its use in orthopaedic and dental implants[7]. Titanium can be alloyed with other elements such as aluminium (Al) and vanadium (V) to increase its strength. Approximately one third of all hip and knee endoprostheses have been successfully manufactured with the alloy Ti6Al4V[8]. In addition to the above elements, alloys with zirconium (Zr), niobium (Nb), palladium (Pd) and indium (In) are also being investigated for their good mechanical properties. Both corrosion resistance and improved biocompatibility compared to Ti-6Al-4V alloy[9]. Ti alloys containing zirconium (Zr) show better tensile strength and fatigue resistance compared to cpTi[10]. Zirconium-containing alloys have high corrosion resistance in biological fluids in addition to mechanical strength[11]. Ti-Zr alloys have better biocompatibility compared to cpTi[12,13]. Because of these properties, titanium alloys are widely used in dentistry and a number of new alloys with non-toxic elements have been developed[14]. Since there are alloys that have some disadvantages, this also applies to Ti-Zr alloys. Since titanium and zirconium have the same crystal structure, they're infinitely soluble in each other. Zirconium is a stabiliser of the beta phase of titanium as a favourable phase in biomaterials, leading to satisfactory properties[15-16].

Powder metallurgy is an extremely important branch of modern industry and is developing rapidly and continuously. Powder Metallurgy is used to produce a wide range of materials[18]. It involves the production, processing and consolidation of fine metal particles that can be used in engineering components. The main feature of this technology is the reduction of costs and material, while the mechanical properties play a subordinate role[19].

In this work, the densification of a biomedical titanium alloy with 20 at% zirconium produced by powder metallurgy was analysed.

2. Materials and methods

Titanium and zirconium powders were used as starting raw materials. The purity of titanium and zirconium powder is 99.8 %. The particle size of titanium powder is 125-250 μm and of zirconia 150 μm. Eight samples with chemical composition Ti-20Zr (at.%) were prepared. After weighing the titanium and zirconium powders, they were mixed. In this research, titanium and zirconium powders were mixed in a ball mill for 30 minutes at room temperature. From the mixture obtained, 8 samples were separated, each with a mass of about 2.5 grammes. The powders were compacted by uniaxial pressing in a hydraulic press. A pressure of 80 MPa was applied to 4 samples and a pressure of 160 MPa to the remaining 4 samples. Disc-shaped specimens were produced. Sintering of the Ti-20Zr alloy samples was carried out in a tube furnace under argon atmosphere with the parameters listed in Table 1. The density of the samples was measured, a very important property of sintered materials, which depends on the proportions of the individual components.

Table 1: *Mechanical properties of selected powder materials.*

Sample No.	Compacting pressure (MPa)	Temperature of sintering (° C)	Time of sintering (h)
1	80	1100	2
2	80	1350	2
3	80	1100	4
4	80	1350	4
5	160	1100	2
6	160	1350	2
7	160	1100	4
8	160	1350	4

3. Results and discussion

To calculate the green density, the green samples were weighed after the compaction process, each of them having a mass of about 2.5 grammes. Their dimensions, diameter and height were measured.

The densities of the green compacts were calculated and are shown in Table 2. The calculated density values were compared with the theoretical density of the Ti-20Zr alloy (4.83 g/cm^3).

Table 2: *Green density values.*

Sample No.	ρ_g, g/cm^3	% of ρ_t
1	3.96	81.99
2	3.90	80.75
3	4.04	83.64
4	4.07	84.26
5	4.11	85.09
6	4.26	88.20
7	4.23	87.58
8	4.21	87.16

The results listed in Table 2 show high density values of all samples already after compaction. They are between 80.75 and 88.20% of the theoretical density. The density values are slightly lower for samples 1 - 4, which were compacted at a lower pressure (80 MPa), while the densities of samples 5 - 8, which were compacted at a higher pressure (160 MPa), show higher values. The dependence of the green density calculated from the dimensions of the compacts on the compaction pressure applied is shown in Fig. 1.

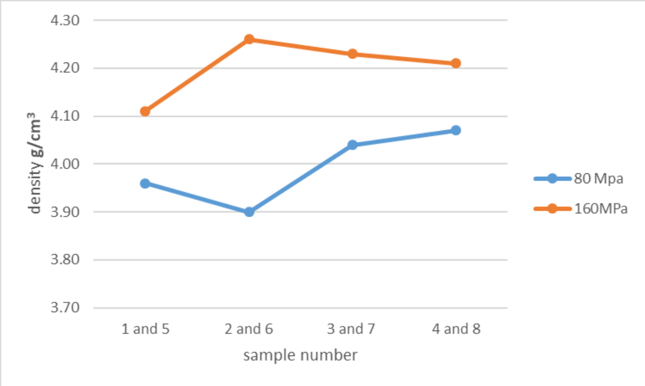

***Fig. 1** Dependence of green density on applied pressing pressure.*

From the graphical presentation it is clear that to achieve higher density values it is more advantageous to apply a higher compaction pressure. This is due to the fact that the compressibility of the powder mixture increases with increasing compacting pressure, which is to be expected with uniaxial compaction of the powder.

The sintered samples were first weighed to determine their mass and then their dimensions (diameter and height) were measured. The mass of the sintered samples was about 2.5 g. Based on the results obtained, the density values of the sintered samples were calculated. The values obtained are listed in Table 3.

***Table 3:** Density values of the sintered samples.*

Sample No.	ρ_S, g/cm^3	% of ρ_t
1	3.84	79.50
2	34.13	85.51
3	4.06	84.06
4	4.14	85.71
5	3.97	82.19
6	3.95	81.78
7	4.15	85.92
8	4.23	87.58

The density values obtained for the sintered samples range from 3.84 g/cm^3 (sample no. 1) to 4.23 g/cm^3 (sample no. 8), which is compared with the theoretical density value of 79.50 - 87.58 %. Comparing these values with those of the samples before sintering, it can be seen that not all samples show an increase in density. This can best be seen in Fig. 2.

Fig. 2 clearly shows how the sintering process increased the density of samples 2, 3, 4 and slightly that of sample 8. Samples 2, 3 and 4 have in common that they were pressed at the same, lower pressure of 80 MPa. The density after sintering depends not only on the compaction parameters, but also on the sintering parameters, as shown in Figs. 3 and 4.

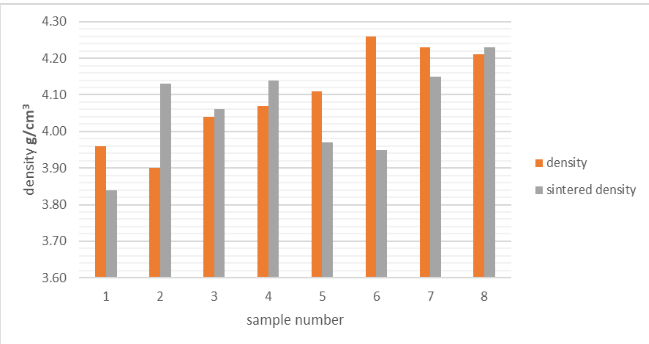

***Fig. 2** Comparison of density before and after sintering.*

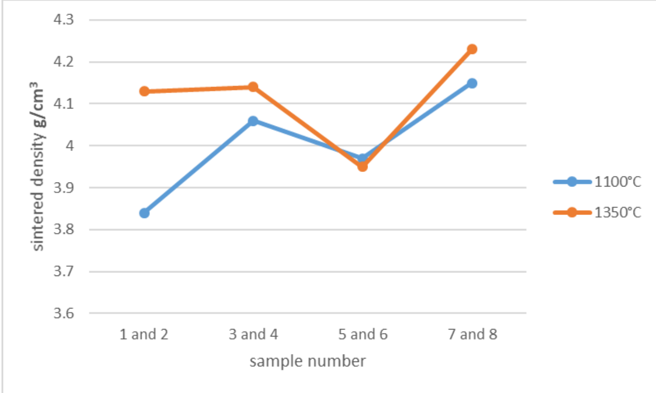

***Fig. 3** Dependence of sintered density on sintering temperature.*

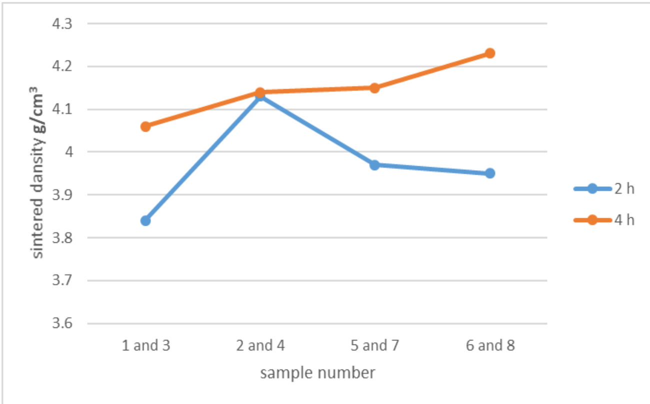

***Fig. 4** Dependence of sintered density on sintering time.*

The figures show graphically that a higher sintering temperature (1350 °C) is more favourable to achieve a higher sintering density. However, this does not apply to samples 5 and 6, which already had high density values before sintering. The achievement of higher sinter density values is also favoured by a longer sintering time (4 h) during which compaction takes place.

The densification or shrinkage of the samples is a consequence of sintering. However, during sintering there may be an increase in the dimensions of the samples, indicating that an increase in porosity rather than the desired increase in density has occurred. Figs. 5 and 6 clearly show the dimensional changes that have occurred as a result of sintering.

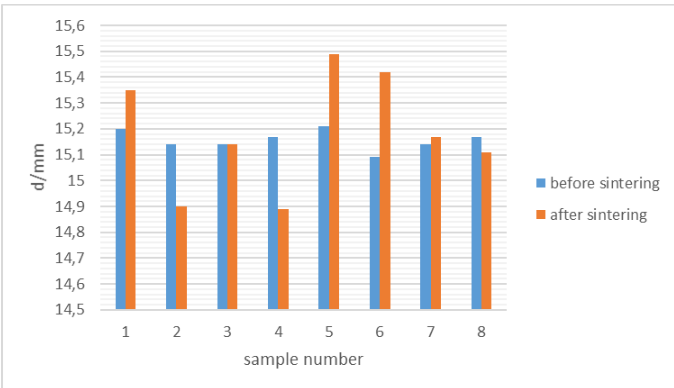

***Fig. 5** Change in the diameter of the samples due to sintering.*

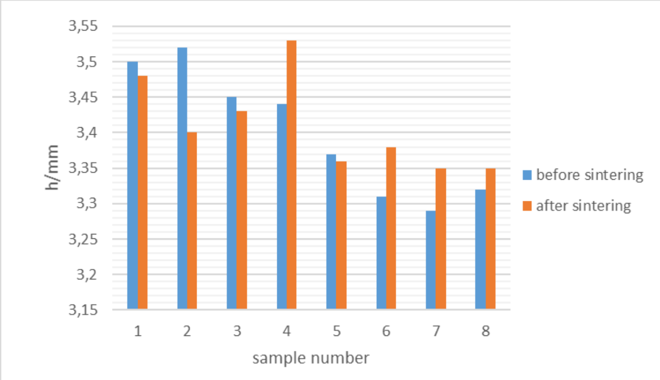

Fig. 6 *Change in the height of the samples due to sintering.*

Namely, these graphical representations show clear changes in the dimensions of all samples caused by sintering. Dimensional changes or quantification of the effect of sintering on the geometry of the samples is best expressed by the densification coefficient ϕ calculated for each sample using the formula:

$$\Phi = \frac{\rho_s - \rho_g}{\rho_t - \rho_g} \cdot 100\%. \qquad (1)$$

The volume change that occurred during sintering was calculated according to the following formula:

$$\frac{\Delta V}{V} \approx \frac{\Delta h}{h} + \frac{2\Delta r}{r}. \qquad (2)$$

The calculated results are shown in Table 4.

Table 4: *Compaction coefficient, changes in volume and mass of the sintered samples.*

Sample No.	Φ	ΔV/V, %	Δm, %
1	-13.79	1.51	-1.21
2	24.73	-6.75	-1.05
3	2.53	-0.58	-0.10
4	9.21	-0.94	0.43
5	-19.44	3.31	-0.14
6	-54.39	7.37	0.12
7	-13.33	2.32	0.09
8	3.22	-5.65	0.50

These results show a wide range of compaction coefficient values between -54.39 and 24.73. Negative values of the compaction coefficient indicate expansion, positive values indicate porosity[20]. The dependence of the compaction coefficient on the pressing pressure is shown in Fig. 7.

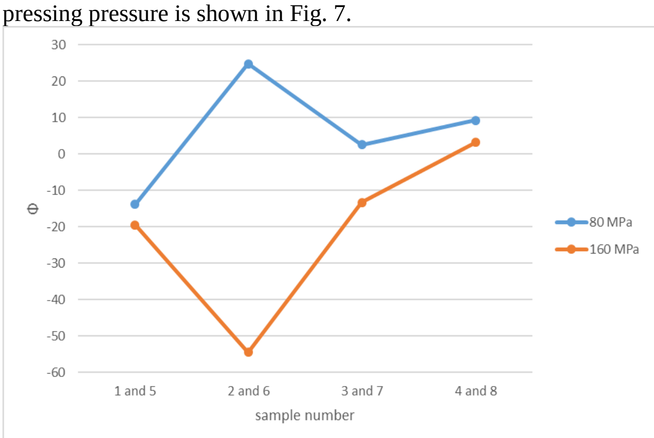

Fig. 7 *Dependence of the densification coefficient on the pressing pressure.*

From this graphical representation it can be seen that the coefficient of compaction is lower for samples that are compacted with higher pressure. This dependence was also found in the work of M. Laska at al.[20].

The dependence of the compaction coefficient on the sintering temperature is shown in Fig. 8. It is obvious that the values of the compaction coefficient increase with an increase of the sintering temperature. This means that densification becomes more pronounced at higher temperatures, indicating that diffusion of the alloying element (zirconium) is complete. An exception is sample 6, which had the highest density before sintering and whose porosity increased due to the sintering process, i.e. most of the thermodynamic energy of the system was spent on diffusion and homogenisation of the chemical composition instead of densification of the compact.

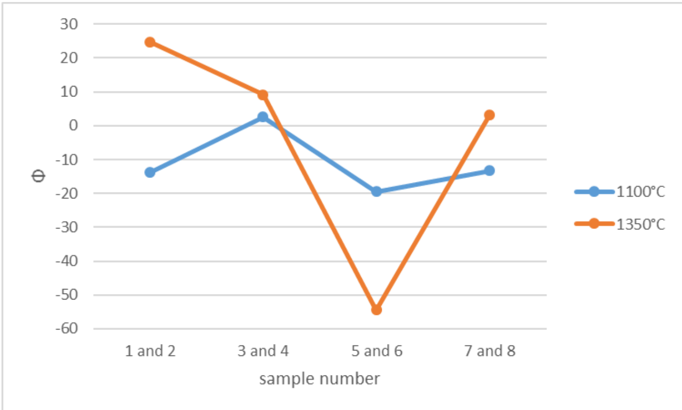

Fig. 8 *Dependence of the densification coefficient on the sintering temperature.*

From the graphical representation in Fig. 9 it can be seen that the volume change after sintering is more pronounced at higher temperature.

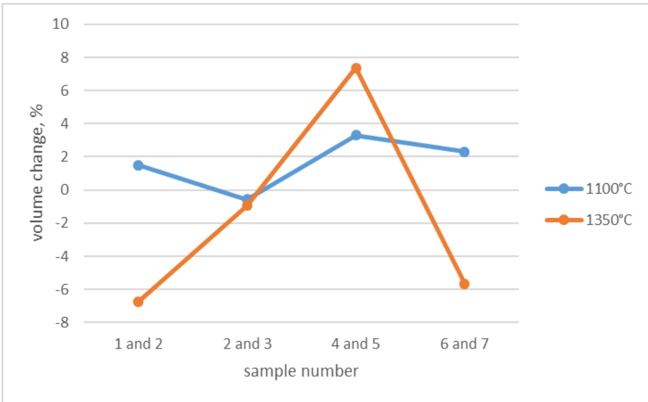

Fig. 9 *Dependence of volume change on sintering temperature.*

Looking at the dependence of the volume change on the sintering time (Fig. 10), it can be seen that the volume changes are more pronounced with shorter times.

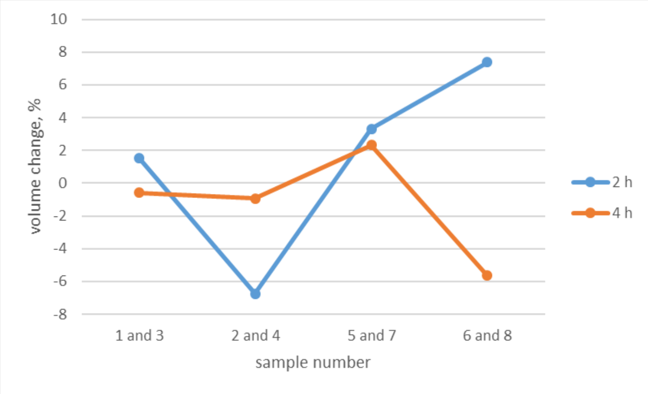

Fig. 10 *Dependence of volume change on sintering time.*

4. Conclusion

In this work, eight samples of a titanium-zirconium alloy with chemical composition Ti-20Zr were prepared by powder metallurgy technology. The results were determined and analysed using appropriate characterisation methods, from which it can be concluded that:

- the value of the density depends on the pressure at which they were compressed; the value is lower when the pressure is lower and higher when the pressure is higher,
- the compressibility of the powder mixture increases with increasing compaction pressure,
- after sintering, the density values are lower than before sintering,
- to achieve higher sintered density values, a higher sintering temperature and a longer sintering time are more advantageous,
- the compaction coefficient is lower for samples compacted at higher pressure, and its value increases with increasing sintering temperature,
- the volume change is more pronounced after sintering at higher temperature, but also at shorter time.

Finally, from the results of the densification analysis of the titanium alloy with zirconium addition, it can be concluded that with the adjustment of the process parameters, it is possible to produce an experimental alloy that has the potential for application in biomedicine.

5. References

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