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An integrated approach to modeling innovative aging

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Abstract: *The rapid development of communication and information technologies not only reduces risk but also strongly influences the ability of industrial companies to develop innovation activities faster and more purposefully. A dynamic and difficult to predict environment has been created in which companies are forced to flexibly seek alternative solutions to the negatively influencing factors in their operations. There are numerous tools and models for strategic development and evaluation of innovation. Most of them describe the problem statically, i.e. at some point in the company's development until the components of time and innovative aging are taken into account. The purpose of this article is to propose a new approach to modeling innovative aging. In this way, the influencing factors will already be present in the methodology for innovative development. Therefore, a new, integrated, approach of methods and tools is needed to realize an effective innovation system.*

Keywords: INNOVATIONS, INNOVATIVE MODELS, INNOVATIVE AGING AND MORE.

1. The essence of innovative development and stay

1.1 Innovative development.

- Impact of innovative development on technology. It arises from the refinement of existing ones and the construction of principally new machines, apparatus and equipment. By purpose and rate of productivity growth, they can be divided into two main groups: machines and equipment with special requirements designed for the production of homogeneous production on a mass scale; and machinery and equipment designed to perform a diverse activity, with universal purpose. In recent years, there has been a trend of strong unification and standardization of the elements in the units of machines on a modular basis.[4] The purpose is to create conditions for rapid assembly of machines with different technological purposes, but with universal purpose, for the needs of the new cyber requirements.

The study of the regularities of the development and refinement of the special purpose and universal technique makes it possible to determine the period during which the greatest effect can be obtained from a given generation of machines intended for a particular production process, and at the same time the period for passing towards the production of new types of machines for the new intelligent production systems. The study of the regularities of the development and refinement of the special purpose and universal technique makes it possible to determine the period during which the greatest effect can be obtained from a given generation of machines intended for a particular production process, and at the same time the period for passing towards the production of new types of machines for the new intelligent production systems. Under the current conditions of accelerated scientific and technological progress, the importance of this field and its manifestation on the pace and scale of innovative aging of the technology has significantly increased. The real consequence of this impact is to increase the scope and timeframes for innovative aging of machinery and equipment in service and the rapid change in their structural composition.[1]

- Innovative development is the creation of new materials. They have an active impact on accelerating the innovative aging of existing equipment. This influence is conditioned by the widespread use of new materials, alloys, plastics, and others, adapted to the processing of certain types of machines. The scale of their use in manufacturing depends on the proportion of unnecessary machinery that is adapted for processing old materials.[10] Many experts believe that the shortened life of industrial products and equipment is achieved partly through the use of lower quality materials.

- This is the impact of innovative development on technological processes. The changes occurring from the application of new technologies in any case play an active role in the production process, as a result of which the relative share of the old technological processes and with them the machines and equipment used for this purpose are constantly reduced.
- It is related to the vocational training and refinement of the methods for raising the qualification and training of the staff. Substantial changes occur in the qualifications of the staff, as a result of which a large number of new professions arise, old ones disappear, changing the ratio between the different groups of professions. The development of the technique entails significant changes in the methods of its operation, on the one hand, and on the other, the improvement of the methods for changing the nature of work and improving the qualification of the personnel.

1.2 Innovative aging.

At the present stage of technical development, innovative aging is of paramount importance to the physical. Therefore, a particularly important point in this regard is the correct determination of the degree of innovative aging. The aim is to identify the impact of innovation on the technical and economic and social results of industrial activity. Correct assessment of their impact on the scale and timing of innovative aging is essential to eliminate the negative effects of their impact in a timely manner. The two strands of innovative aging have an impact on this process.[2]

- The first strand of innovative aging is an inevitable consequence of innovative developments in technology and technology worldwide. This area of innovative aging arises under the influence of innovative solutions, expressed in the designed, introduced into production new, more modern, more productive and with better technical and economic indicators of machines, apparatus and equipment in comparison with the ones made before them. In these cases, the efficiency of the application of the old machinery and equipment will be significantly lower, and they themselves will be depreciated to some extent. The effect of using such a technique will be reduced, and the magnitude of this decrease will depend on the strength of the factors that characterize their innovative aging.
- The second strand of innovation aging arises under the influence of innovative solutions that have the character of local impacts or innovations of local importance. The effect of using old technical and technological solutions will be reduced and the magnitude of this decrease will depend on the strength of the factors that characterize their innovative aging. Innovative aging in both directions contains some of

the features that most fully reveal its nature and the economic consequences of its impact on the elements of production. The main feature is that it causes partial or complete depreciation of machines, apparatus, equipment and other elements and their customer value, which results in the need to replace technically outdated equipment with new, before its physical wear and tear has expired. The economic feasibility of such a replacement is not determined by the very fact of the appearance of new machines of similar technological purpose, but by the degree of innovative depreciation of the existing machines and equipment and the level of reduction of economic efficiency from their continued use. However, it should be borne in mind that the loss of consumer value and the need to replace machines is driven by a number of factors reflecting the specific directions of the impact of innovative development.[9]

Taking into account those factors that characterize the qualitative side of innovation development and aging, it is possible to reveal not only the mechanism of its impact on production efficiency indicators, but also its impact on different sides of the production process.

2. Integrated modeling approach.

In order to accurately and properly account for the benefits and effects of innovative development and innovative aging, the development of the problem should be considered in a comprehensive way. This means that the qualitative nature of components such as, degree of innovation, innovation activity, innovation aging and alternative solutions to rapid innovation aging are considered as a comprehensive integrated approach to the solution. [7] The integrative nature of this approach is based on the fact that it involves more influencing factors that affect the efficiency of innovation activity of industrial firms. The solution structure includes several models defined as;

- Model for determining the degree of innovation
- Model for innovation activity
- Model for innovative aging
- Model for alternative solutions

2.1 A model for determining the degree of innovation.

Mathematical models can also be applied to determine the degree of product and process innovation, and specific indicators defining the concept of innovation as novelty, applicability and commercial realization can be used to solve them.

- technical indicators (novelty)
- a metric that defines the user nature (applicability)
- commercial realization (market)

The model for determining the degree of innovation is used to calculate novelty in cases where it is sufficient for a particular research objective to focus on the innovative nature of the problem.

- Technical, consumer and market indicators or

$$C_{ino} = C_{teh} + C_{pot} + C_{mt}$$

are used in the development of innovative products, the degree of innovation being defined as the sum of the results of the separate indicators taken as relative weights, subject to the condition:

$$C_{teh} \leq 1; C_{pot} \leq 1; C_{mt} \leq 1;$$

$$C_{ino} \leq 3 - \text{Степен на иновативност.}$$

- Technical indicators (C_{teh}). They calculate the savings of materials, labor, energy, quality improvements and more. of the new product compared to the old product or similar to it.
 - C_{teh} - technical indicator (novelty).

- Consumer Metrics (C_{pot}). They predict the number of consumers (C_{pot}) who will adopt the new product and use empirical dependencies to diffuse innovation.
- Market Indicators (C_{mt}). These are sales metrics and include three components:
 - C_{inv} - investment costs;
 - C_{kk} - quality;
 - C_{eko} – ecology

2.2 Model for innovation activity.

The determination of innovation activity over a given period of time, with predefined parameters, can also be modeled. The innovation activity model reveals how products are perceived as attractive between real and potential consumers. [8] The innovation model can be widely used in product and technology forecasting. The mathematical basis of the innovation activity model is the diffusion model.

The formulation of the model is based on dependence:

$$S(t) = m \cdot f(t),$$

- where: $f(t)$ - the degree of change in the activity accepted or introduced;
- m - potential;
- $S(t)$ - the sale or degree (s) of the change in the accepted introduced activity, that is, the perception.

Then the innovation activity can be expressed by $S(t)$ or:

$$S(t) = \frac{m(p+q)^2}{p} \cdot \frac{e^{-(p+q)t}}{1 + \frac{q}{p} \cdot e^{-(p+q)t}}$$

- p - the coefficient of innovation, taking into account external influences or advertising effect;
- q - coefficient taking into account internal or functional effects;

Experimental values of p and q are taken from the table.

The model is suitable for use in a wider range of innovative products, although the solutions vary widely, mainly in pricing and advertising.

2.3 Model for innovative aging.

Innovative aging is measured by the degree of impairment of some of the features of old machine designs compared to that of newly produced innovative ones. Their determination is carried out in the following sequence by the formula;

$$M = W \cdot K$$

Where:

- M - innovative aging, (depreciation of the functions of old machines) (BGN);
- W - initial value of the old machine (BGN);
- K - Ratio for the level (%) of innovative aging ($0 < K < 1$).
- K moves in the range $0 < K < 1$, where:
- $K = 1.0$ no innovative aging (machine is 100% innovative).
- $K = 0.5$ the machine is half innovatively outdated or 50%.
- $K = 0.0$ the machine is completely innovative outdated or 0% innovative.
- K - defines innovation only in the range from 0 to 1.

$$K = (1 - E) \text{ where:}$$

- E - the degree of innovation of the machine at a given moment (at the time of measurement).

3. Degree of innovative aging.

The degree of innovation (E) is determined by how much a machine is more innovative (%) than the comparable machine. It is defined as follows:

$$E = \frac{D1}{D2}$$

Where:

- D1 - ratio of the value of the new machine to the value of the old one.

$$\text{Or } D1 = \frac{V2}{V1}$$

Where:

- V2- Value of the new machine.
- V1- Value of the old machine
- D2 - the ratio of the performance of the new machine to the performance of the old one.

$$\text{Or } D2 = \frac{Q2}{Q1}$$

Where,

- Q2- Performance of the new (innovative) machine.
- Q1- Performance of the old machine.

We replace and receive: $K = 1 - \frac{D1}{D2}$

Further clarification of the individual indicators given above;

- The ratio $\frac{D1}{D2}$ must be positive (+) indicating that we have innovation, or the degree of innovation of the machine is growing. If the ratio (-) is negative, the conclusion is that the innovativeness of the machine is decreasing or the machine is not innovative. In essence, this means that D2 must be prioritized over D1, or the price of the new machine should be in optimal proportion with the price of the old machine. And the performance of a new machine should always be higher than the performance of an old machine;
- At V2 = 0 and Q2 = 0 then D1 = 0 and D2 = 0;
- Determining the length of production periods for types of machine structures such as;
 - Conventional or Class A, these are traditional machines and Class A1, these are machines where the reliability / warranty / service life indicators are the same over time.
 - Mechatronic (Modular Principle). They have an optimal ratio of reliability / warranty / service life indicators.
 - Machines for cyber systems
- The ratio (1- E) can be of the n-th degree when we follow the development of the innovation process of innovation with world novelty.
 - n I - another innovation against which it is measured (serves as a baseline).

- h - scale factor (0.5 to 1.00) Scope of the manifestation.
- h = 1, at n = 1, applies only to innovations with worldwide novelty.
- h = 0.5 at n = 0.5, applies only to innovations with a regional scale of innovation impact.

Then:

$$K = (1 - E); \quad E = \frac{D1}{D2}$$

4. A model for alternative solutions to rapid innovation aging..

The rapid innovative aging of products and services poses to humanity the solution to the problem of eliminating the harmful effects of its impact. This is especially necessary for the issuance of security documents, such as patents, where the period for their issuance is longer than the appearance of a new innovative solution. Or is the product innovatively outdated before it is put into service. With the current development of computer and information technology, this problem can be solved by the creation of a European or World Information Center with open access to the database. Patents should only be granted for products and technologies that have a proven long innovation life. For all other inventions open access to them through a fee. , or,

$$AR = F(a, r, I);$$

- A - the degree of innovation;
- R - innovation activity;
- I - innovative aging;
- AR - Alternative solutions against rapid innovation aging;

5. Innovation aging in the context of the digitalization of industry.

The concept of digital transformation of innovative aging is to create the preconditions for the modernization, automation and competitive development of industrial enterprises in the medium to long term. It is dictated primarily by the rapid growth of new technologies, leading to the rapid automation and digitization of real production and business processes, as well as the emergence of qualitatively new relationships to create value.

Digitization covers diverse activities, business models and technological solutions. On the one hand are the development of e-business and e-commerce, automated industrial production and intelligent manufacturing enterprises, intelligent transport systems and vehicles, intelligent energy systems and more. Cloud technologies, Internet technologies, including the Internet of Things, technologies for harnessing the potential of big data, industrial and service robotics, the development of artificial intelligence are the main technological prerequisites for the development of the digital economy.[5] Adopting common technology standards is to ensure interoperability between systems and to ensure their reliable operation, as well as compliance with confidentiality, security and accessibility requirements. Digitizing production can greatly lead to intelligent automation of the industry.

The new industry requirements are a collection of related digital technology solutions that support the development of automation, integration and real-time data exchange in manufacturing processes. In essence, this reflects an industrial and technological transformation process that naturally follows the development of scientific and industrial practices.[6] The fourth industrial transformation is a natural continuation of the digitization and automation of production and involves internet connectivity and interaction of cyber-physical systems without human involvement. Processing and analysis of large information arrays and decision making of artificial intelligence, robotics, use of digital clouds, digital modeling and simulation of production processes.[3] This is done through virtual reality, intelligent automation, mass production of individualized products, the emergence of new technologies,

creation of new technological and business models. In this respect, Industry 4.0 is defined as part of the application of new digital technologies in the manufacturing sector and includes a wide range of technological solutions and technological and business models that contribute to qualitatively new forms of innovation activity.

6. Conclusion

In conclusion, we can accept that a global solution to this problem is needed. In addition, technological developments and, in particular, their consequences, manifested in the form of various types of innovative and planned aging of products and processes, are leading manufacturers to look for ways and means to master this process. The trend of changing the parameters of industrial products and processes as a result of human intervention for their rapid aging, also known as "planned aging", is already forming a new alternative concept for their development. It also places new demands on both the consumer nature of industrial products and the methods, approaches and methods of their production, consumption and evaluation.

In order to accurately and properly account for the benefits and effects of innovative development and innovative aging, the development of the problem should be considered in a comprehensive way. Their development must integrate and take into account the impact of a large number of external and internal factors, which means a change in the qualitative nature of the components. The main components such as the degree of innovation, innovation activity, innovation aging and alternative solutions to rapid innovation aging should be considered as a comprehensive integrated approach to the solution. The integrative nature of this approach is based on the fact that it involves more influencing factors that affect the efficiency of innovation activity of industrial firms. And it reduces the losses from rapid innovation aging.

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Apply an innovative approach to deriving the value of the synergistic effect

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Abstract: Synergistic value is a special value that also includes additional elements of value created by the amalgamation of two or more assets along the value chain. In addition, the synergistic value indicates the value of the combined interest of its participants and is greater than the total value of the individual assets evaluated. The purpose of this article is to analyze the situation of a number of companies generating this part of the synergistic effect. This innovative approach is based on a revenue approach and incremental cash flows are generated. The way in which the value of the synergistic effect is derived is of particular importance for all stakeholders, with the applicable methods being: Cost method and revenue method.

KEYWORDS: ASSET VALUATION, SYNERGISTIC VALUE, MARITAL VALUE, MANAGEMENT, NET PRESENT VALUE.

1. Nature and development of the problem. .

In optimizing the performance of the enterprise and maximizing the value of the capital, managers strive to present in their financial statements, all assets and liabilities of the company at fair values, through adequate financial and management decisions. However, they do not use value inference through the Synergistic Effect. In this case, different approaches are used in the world practice to determine the “fair value” of an entity (enterprise, firm, unit, etc.). In the case of regulated output through synergies - the importance of the problem is dictated by the principle of fair and fair presentation of assets / performance and balance sheet balance, on the one hand, and the reflection of the added value of synergy in management reports.

The synergistic effect (by Synergos Greek - we act together.) Is an increase in efficiency as a result of integration, mergers of individual parts into a single system as a result of the appearance of a systemic effect). The synergistic effect is formed by the effects of different components whereby the effect exceeds the algebraic sum of the effects of each component taken separately. Synergy can be both positive and negative. The positive effect can be achieved either by increasing revenues or by reducing costs as a result of the integration of the effects of the various components in the economic system. As a result, competitiveness is increased, the efficiency of the resources used is increased, the ability to generate and use new innovative methods and conquer existing markets, as well as the development of new ones, is increased.

The limited conditions under which synergy has the potential to create a competitive advantage are;

1. Synergies should demonstrate a reduction or optimization of costs and an increase in revenue above the cost of acquisition. This is the effect of implementing the strategy. The effect will be reflected on the stability of the company.

2. Synergies must be valuable, unique, scarce, with no substitutes. It is not imitated when competitors who do not own it face additional costs and time to secure it¹

The quantitative estimates of the synergistic effect are diverse. In the world practice different approaches and methods are used in determining the “value” of an object (enterprise, firm, separate part and others) in the case of equity. Equity represents the size of the owner's share of the property after deducting all liabilities.

According to Weston and Weaver, synergy (efficiency) is due to the wide range of sources presented in adapted Table № 1

The associated costs, including those of the integration process, should also be taken into account in the calculated value of the synergy²

A major problem in accounting for the costs incurred to generate synergy is how to keep these costs in line with the concept of “value for money”.

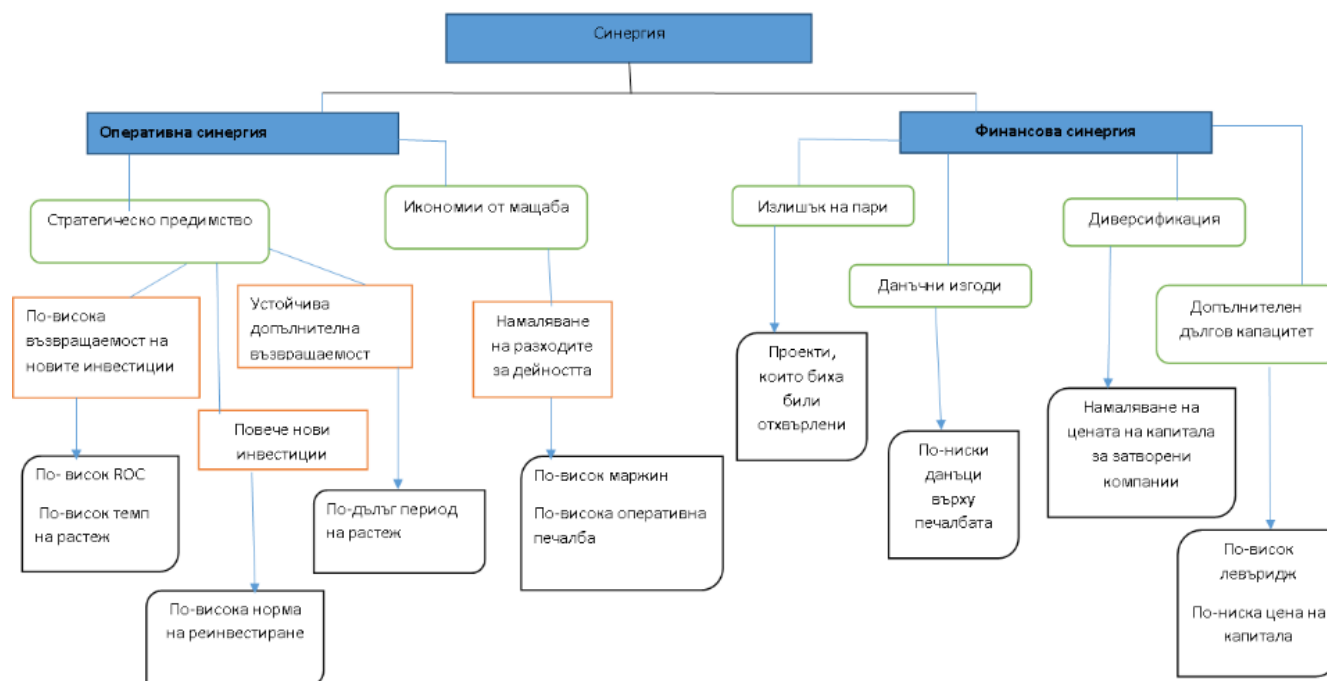
The success of realizing the synergistic effect depends on the correct moment of the transaction - sometimes it is necessary to rush and work with shorter deadlines, and at other times it may be necessary to wait or to work with longer deadlines. . Therefore, identifying the necessary time for synergy to manifest and the likelihood of this occurring are the key points in determining its true value.

Table № 1 Sources of Synergy in M&A Transactions

Definition	Source Manifestation
Strategy	Development of a new strategic vision; Acquisition of skills in a new industry; Rapidly entering new markets with new products; Application of a wide range of abilities and management skills in new fields
Economies of scale	Reduction of production and administrative costs due to volume; Combining research and development; Strengthening the distribution system
Reach savings	Expansion of product lines; Providing complementary products
Advantages of scale	Access to high-tech equipment; Significant discounts
Good practices	Operational efficiency; Rapid tactical application; Resource optimization
Market expansion	Market share growth; Access to new markets
New abilities / Skills	Acquisition of capabilities in new industries; Security of rapid development personnel
Competition	Business acquisition before competition; Competition based on EBIT growth
Customers	Developing new relationships with key clients; Satisfaction of needs for a wide range of services
Technology	Entry into technologically dynamic industries; Acquisition of new R&D capabilities, patents
Change in the industry	Deregulation, relief of state barriers to the geographical and product development
Enlargement of Industries	Combining Multiple Small Businesses into One Large (roll up) and take advantage of experienced management
Globalization	International competition; Opportunities for growth outside the local market; Diversification; Access to cheap resources

¹ Grant, R., contemporary strategy analysis: Concepts, techniques, applications, Malden, MA:Blackwell Publishers, 2005

² Brealey, R., Myers, S., Allen, S., Corporate Finance, New York, McGraw-Hill, 2005



It is a difficult task to identify revenue synergies that are more difficult to measure than cost synergies (given its intangible nature). For this reason, in practice, revenue synergy is often referred to as soft dollar synergy, and nearly 70% of M&A transactions fail to deliver on their expected values³.

The synergistic effect depends on markets, competition and customers, respectively, dependent on volumes and prices, which makes it difficult to control by the merged company. The relationship between the two types of synergy (cost reductions can lead to missed revenue) and the combined effect of the two must be observed.

According to Bulgarian Standards for evaluation (BSV), section 1, item 1.5.1. "Value" for the purpose of valuation of objects / assets, is the opinion of an independent valuer, reflecting the value and value of the object / asset, expressed in money, for a specific purpose, at a certain point in time, over time and in the context of a particular market and taking into account relevant circumstances in the course of the valuation.

In the specific report it is necessary to indicate the value of the Synergistic effect, which in the separate evaluation standards is as follows:

The value of a going concern or separate entity is not a value standard (standard) but an assumption of the state of the venture at the time of the valuation. It is the value of an enterprise or a proportion of it that is considered as a viable economic entity. The relationship between synergy and the value of the merged company⁴

2. Sequence of application of the approach in the practice.

The synergistic value is derived by applying all appropriate and applicable approaches and methods, taking into account the elements of complementary and integrative activities and factors that can form a pooled interest and create additional benefits.

This is the value of the Synergistic effect of the financial investments made. A number of factors affect the size and shape of the original price of the transaction, their importance being determined by the specifics of the transaction.

Some factors are quantified (eg synergy), while others are fully subjective.

Based on BSV Part II, Section Five, "Specific and specific requirements for the assessment of MSW are recorded in section 6.3:

* The value of reputation may vary depending on the purpose of the valuation and include elements such as:

* Enterprise-specific synergies resulting from a business combination (such as reduced operating costs, economies of scale, or product mix dynamics),

One of the main approaches used is the estimation of the market values of the individual elements involved in the synergistic effect evaluation system. Avdonina S. In this case, the synergistic effect is a consequence of the integration of the activities of different companies and activities in a single integrated management and management system. This has an impact on the value of the company. By principle, there are three main approaches to assessing Companies:

being. This method is applicable to countries with developed stock markets;

❖ Income approach.

It is based on the enterprise's potential to generate income and profits. Different valuation methods may be applied based on projected flows and financial results.

3. Results from the practical application of the approach.

For Company X combining 4 companies, the calculated effect by the two methods shows the following.

- Total value of separately combined assets - EUR 3180 thousand.
- Synergistic value of these assets - EUR 3720 thousand

³ Early, S., Mergers and Acquisitions: New McKinsey Research Challenges Conventional M&A Wisdom, Strategy & Leadership, volume 32, issue2, 2004, p.4-11

⁴ Damodaran. A., The value of synergy, New York, Stern School of Business, Working paper, 2005

BVS	ESV	IVS
Synergistic value is a special value that also includes additional elements of value created by the merger of two or more objects / assets. The synergistic value indicates the value of the pooled interest and is greater than the total value of the individual assets / assets evaluated.	Synergistic Value (also known as Marital Value) "An additional element of value created by the amalgamation of two or more interests when the value of the combined interest is greater than the total value of the two original interests" (IASB, 2007, p. 88 and 414) EVS 2 ESTIMATED BASES OTHER THAN MARKET VALUE 4.3.5. Synergistic value - this is a separate type of special value that valuers often encounter, and is also known as 'marital value'. 4.3.7. Comment - when a special value arises when a pooling of interests results in a greater value than the aggregate value of those interests, which are assessed separately, this value is often described as "synergistic value" or "marital value". The terms of the engagement and the valuation reports must clearly state that such values are required or will be provided and the market value should also be taken into account to determine the difference between the two bases.	70. Value Base as defined in IAS - Synergistic Value 70.1. Synergistic value is an additional element of value created by the combination of two or more assets or interests, where the combined value is greater than the sum of the individual values. If synergies are only available to one particular buyer, then the synergistic value will be different from the market as it will reflect specific characteristics of the asset that have value only for a particular buyer. This added value over and above the sum of relevant interests is often called "marital value." 180. Subject-specific factors 180.1. For most value bases, factors that are specific to a particular buyer or seller and are not available to participants are usually excluded from the baseline valuation. Some of the subject-specific factors that may not be available to participants are: (a) the added value or reduced value resulting from the creation of a portfolio of similar assets, (b) unique synergies between the asset and other assets held by the entity, (c) legal rights or restrictions with respect to the entity alone, (d) tax breaks or burdens unique to the entity; and (e) the ability to use the asset in a manner unique to the entity. 190. Synergies 190.1. Synergies describe the benefits of combining assets. When synergies are available, the value of one group of assets and liabilities is greater than the sum of the values of the individual assets and liabilities, which are self-assessed. Synergies are usually associated with cost reductions and / or increased revenues and / or risk reduction. 190.2. Whether synergies should be taken into account in the valuation will depend on the basis of value. For most value bases, only those synergies that are available to other actors should be considered (see the statement on entity-specific factors in paragraphs 180.1-180.3). 190.3. The assessment of whether synergies are available to other actors may be based on the amount of synergies and not on the specific way to achieve that synergy.

Table № 2 Determinants of the size and payment of the bid price⁵

	Factors affecting size	Payment (money, shares, debt)
For the acquiring company	Expected net synergy Expected contribution of the target to the net synergy Tendency to share net synergy with the target company Availability of alternative investment opportunities Existence of competition for the transaction Presence of defensive tactics of the target Transaction transparency requirements Expected control value	Current debt capacity Cost of debt financing Amount of diluted net earnings per share (when exchanging shares) Transaction size Risk Sharing (Payment by installments) Degree of overvaluation of the acquiring company's shares
About the target	Existence of competition for the transaction Expected contribution of the target to the net synergy	Attractiveness of the shares of the acquiring company Shareholders' preferences for cash payment

Deal type (friendly or hostile)	Amount of potential tax liability (preferred stock exchange)
Effectiveness of defense tactics	Target company growth potential (strategic value and additional premium)
Amount of potential tax liability (increases final cost)	
Target company value	
Availability of alternative investment opportunities	

❖ **Expenses approach:** The main method in applying this approach is the Net Asset Value Method. The value in this case is a function of both the market value of the assets and the market value of the liabilities. The value of the Synergistic effect can be determined by the difference between FV equity₁ - FV equity₂, where

FV equity₁ – Fair Value of equity before investment;

FV equity₂ - Fair Value of equity after investment

In this case, this method is not applicable in the absence of complete accurate and objective information about the state of the assets and liabilities of the company.

❖ **Market approach.**

The Market Analogues method is applied. This method is specific and requires thorough research and information about companies - analogues for which there is complete, accurate and objective information about the transactions performed. In this approach, as in the previous one, it is necessary to determine the difference between the GCC1 - GCC2.

This method is not applicable due to the lack of information on analogue enterprises, both for the period before and for the time

⁵ DePamphilis, D., Mergers, acquisitions, and other restructuring activities: An integrated approach to process, tools, cases, and solutions, Elsevier, San Diego, 2012

4. Conclusion

Determining the value of the synergistic effect of acquiring financial assets using the income approach is appropriate and accurate for companies with a large number of companies.

In determining the value of the Synergistic Effect, taking into account all known facts and circumstances related to the activity and prospects, including the state of the company's markets, it can be considered as a good decision.

The result obtained by this method shows in value respect better results using the synegeic approach.

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Some aspects of design and implementation of robotized technological modules and systems

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Summary: This article discusses the features of automation of discrete manufacturing processes. The peculiarities of application of industrial robots are analyzed. A method proposed for the study of roll-over systems, which allows the choice of the optimal solution under specific conditions.

KEYWORDS: AUTOMATION, ROBOTS, INDUSTRIAL ROBOTS, ROBOTIC TECHNOLOGY MODULES, ROBOTIC SYSTEMS, OPTIMIZATION.

1. Features of automation of discrete production processes.

The main goal of discrete manufacturing automation is to produce more, better quality and less human resources, i.e. to increase production efficiency.

There are two types of basic processes in industry:

- Continuous production processes - chemistry, metallurgy, etc.
- Discrete production processes - these are interruptible processes. These processes are over 80% in Bulgaria and worldwide. Discrete are all processes in: mechanical engineering, electronics and electrotechnical industry, pharmaceuticals, food industry, wood processing industry, production of ceramic products, etc. [1, 8]

There are two main approaches to automating discrete production processes:

- Automation of existing machines and equipment based on existing technologies;
- Design of new automated facilities based on the introduction of new technologies.

In the automation of existing machines and equipment, the flow of details is automated, with the universal machines and semi-automatic machines being transformed into automatic machines. In these cases, productivity growth is generally in the range of 1.1 to 2.

When designing new machines and equipment, productivity gains are generally in the range of 2 to 5, but may have significantly higher values, e.g. up to 50. This is possible with the introduction of new innovative automated technologies.

The effect of the automation of discrete production is economic and social.

The economic effect results from the reduction of human resources in the production of certain products, the increase in productivity and the improvement of the quality of the products.

articles. The economic effect can also be determined by the decrease in the cost of production.

The social effect is the reduction of heavy, monotonous and physical labor, often associated with unhealthy working conditions - polluted environment, high noise, shock loads, high temperature, radioactive environment, etc.

2. Features in the application of industrial robots.

Industrial robots (IPs) are the most commonly used automation tools. They can be used for performing auxiliary operations as well as for performing technological operations (welding, painting, installation, palletizing, etc.).

Industrial robots are becoming more and more widely used not only in industry, but also in various fields of services, military, healthcare, elderly care and more.

For the last 10 years, the degree of automation has been steadily increasing. This is also evident from the worldwide sales of industrial robots, which have doubled in size - from about 115,000 units on average over the 2005-2008 period, to 229,261 robots sold in 2014. The main market for robots for 2014 is Asia with 139,300 units (up 41% from 2013), leading Europe - 45,600 units (5% increase over 2013) and America with sales of approximately 32,600 units (8% more sales since 2013). A total of 5 countries hold 70% of worldwide sales: China, Japan, the United States, South Korea and Germany. In Europe, after Germany, the sales ranking for 2014 is as follows: Italy - 6200 pcs. (32% growth), France - 3000 pcs. (36% growth), Spain - 2300 pcs. (decrease of 16% - due to previous investments in the automotive industry), UK

- 2100 pcs. and the Czech Republic, Poland and Turkey respectively.

For the year 2019, the total number of used robots in the world is around 1,800,000 pieces [1].

3. Optimizing the application of industrial robots.

The use of an IP to serve more than one technology unit (TE) in the industry is appropriate in a number of cases. In this way, the redemption period is reduced and the annual economic effect of implementing a decision is increased. When designing robotic technology modules (PTMs) and robotic systems (PCs), there is a need to determine the optimal number of machines served by one IP. Most often, the criterion of optimality is the minimum TE downtime with the maximum IP load.

Problem statement: given a maximum number of TE - N_s served by one PR, machine times T_i and machine service times from the PR - T_{obi} ($i = 1 \div N$), such a solution is sought, which ensures a minimum stay of the working machines at maximum IP load [109], i.e. the optimal number of machines serviced by one robot is found.

In FIG. 1 is a schematic diagram of a robotic system. The following restrictions are adopted: consistent servicing of TEs by the robot; one cycle includes one TE service.

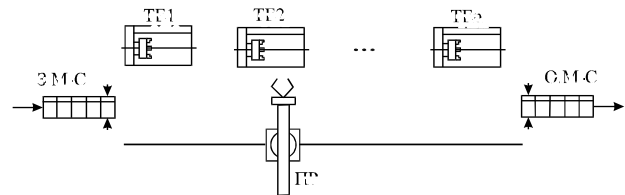


FIG. 1. Schematic diagram of a robotic system

PR - industrial robot;

TE1 ÷ TE_n - technological units;

Z.M-C - supply store-collector;

O.M-C - collecting shop-collector;

In FIG. In order to illustrate the operation of the RTM, cyclograms are given for typical cases when servicing the technological units:

- TEs do not have downtime, PR has downtime when servicing a TE (Figure 2 a)
- PR has no downtime and TE has downtime (Figure 2 b);
- PR and TE have no downtime (Figure 2 c);
- PR and TE have downtime (refers to complete cycle);

For Figure 2. (a) the following machine and service times are characterized by the number of machines being three:

$$T_1 > T_{ob2} + T_{ob3};$$

$$T_2 > T_{ob1} + T_{ob3}; (1)$$

$$T_3 > T_{ob1} + T_{ob2};$$

where: T_1, T_2, T_3 are the machine times of the first, second and third TEs respectively; $T_{ob1}, T_{ob2}, T_{ob3}$ - service times of the PR for the first, second and third TE;

Dependencies (1) can be summarized for any number of machines:

$$T_i > \sum_{j=1}^n T_{o\bar{o}j} - T_{o\bar{o}i}, (2)$$

where: i is the number of the TE served; T_i - the machine time of the i -th TE; T_{obi} - the time for servicing the i -th TE of the industrial robot.

The time for the robot to stay when servicing the i -th TE is determined by the following dependence:

$$T_{np_i} = T_i + T_{obi} - \sum_{j=1}^n T_{obj} , \quad (3)$$

$$T_{np} = \sum_{i=1}^n T_{np_i} , \quad (4)$$

The generalized dependencies for the other typical service cases are similarly determined. For figure 2 (b) the dependencies are defined:

$$T_i < \sum_{j=1}^n T_{obj} - T_{obi} , \quad (5)$$

$$T_{nmi} = \sum_{j=1}^n T_{obj} - T_{obi} - T_i , \quad (6)$$

$$T_{nm} = \sum_{i=1}^n T_{nmi} , \quad (7)$$

For the third case (Figure 2 c), the dependencies apply:

$$T_i = \sum_{j=1}^n T_{obj} - T_{obi} ; \quad (8)$$

$$T_{np} = 0 ; T_{nm} = 0 \quad (9)$$

The fourth case is characterized by dependence:

$$T_n = T_{np} + T_{nm} = \sum_{i=1}^n T_{np_i} + \sum_{i=1}^n T_{nmi}$$

where: T_n is the total residence time of the PR and TE; TPM - total time spent by technological units; Tpr - total time for the stay of the PR;

optimality, the following objective function is ensured, ensuring a minimum residence time for PR and TE:

$$T_n = \sum_{i=1}^n (T_{np_i} + T_{nmi}) \rightarrow \min$$

The mathematical model extracts the form:

$$(12) \quad \begin{aligned} & T_i > \sum_{j=1}^n T_{obj} - T_{obi} \\ & T_{np} = \sum_{i=1}^n \left(T_i + T_{obi} - \sum_{j=1}^n T_{obj} \right) \\ & T_i < \sum_{j=1}^n T_{obj} - T_{obi} \\ & T_{nm} = \sum_{i=1}^n \left(\sum_{j=1}^n T_{obj} - T_{obi} - T_i \right) \\ & T_i = \sum_{j=1}^n T_{obj} - T_{obi} \\ & T_{np} = 0 \\ & T_{nm} = 0 \\ & T_n = \sum_{i=1}^n (T_{np_i} + T_{nmi}) \rightarrow \min \end{aligned}$$

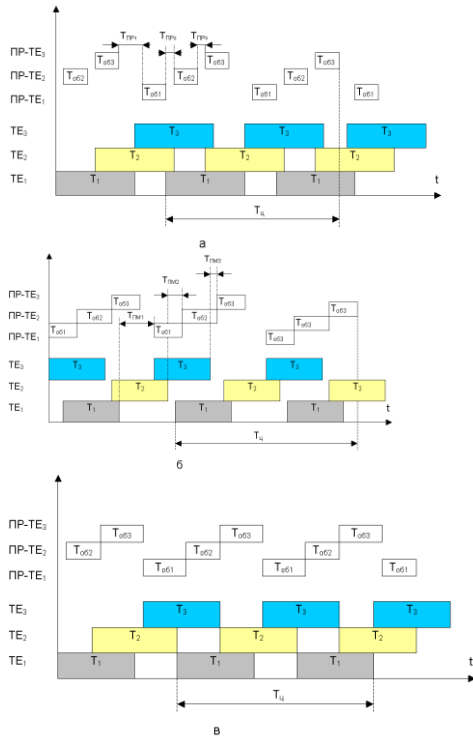


Figure 2. Cycle diagram of RTM operation of three TEs and one IP
a) the IP has downtime; b) they have downtime;
c) PR and TEs do not have downtime;

The set of analytic dependencies presented above forms the mathematical model to support the study of RTM. As a criterion for

Based on the compiled mathematical model (12), an algorithm has been developed whose block diagram is shown in Fig. 3. N , T_i , T_{obi} ($i = 1 \div n$) are set as input variables. different options for multi-machine servicing under IP are considered. The variants depend on the number of TE - n , where $n = 2 \div N$. The state of PR and TE is examined for each of the variants indicated. Depending on the condition, the downtime of the robot in servicing the i -th machine T_{pri} and the technological units T_i , $i = 1 \div n$, is determined. For each variant, the total downtime of the robot T_p and TE - T_{pm} according to (4.9) and (4.12) are calculated.

The total downtimes T_p , $T_p = T_{pr} + T_{pm}$ for each of the variants are calculated using the simple optimization method. For each of the variants both results for the downtime of the IP and the machines, as well as the number of technological units n and the total downtime T_p are displayed. Upon completion of the study, the optimal variant and the combination are minimized. Intermediate results may also be displayed.

An algorithm has been developed based on the mathematical model (12) compiled. N , T_i , T_{obi} ($i = 1 \div n$) are set as variable input data. different options for multi-machine servicing are considered in the IP. The variants depend on the number of TE - n , where $n = 2 \div N$. The state of PR and TE is examined for each of the variants indicated. Depending on the condition, the downtime of the robot in servicing the i -th machine T_{pri} and the technological units T_i , $i = 1 \div n$, is determined. For each variant, the total downtime of the robot T_p and TE - T_{pm} according to (4.9) and (4.12) are calculated.

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Conclusions:

- The basic principles of production automation are discussed.
- Features of application of industrial robots are analyzed.
- A method for testing robotic systems is proposed, optimizing the choice of solution.

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Aspects of efficiency from the implementation of the "MICROSYS" automated system

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Abstract: *The effect of database implementation is to reduce production costs and design time, which will reduce the cost of the product. This necessitates a production-technological analysis and a strategy for further activity and development of the project: "Automated system for structural and technological design of microcomponents and microtechnical products - MICROSYS".*

KEYWORDS: DATABASE (DB), MICROMECHANICAL COMPONENTS (MMC), MICROTECHNOLOGY (MT), PRODUCT INNOVATION.

1. Introduction

The current stage of industrial development is characterized by the globalization of requirements, both for product quality and the need for sustainable growth, and for the pursuit of the purposeful application of highly efficient automated technologies [1].

Sustainable trends in the globalization of the economy lead to accelerated introduction of new technologies, automation of production processes, solving a wide range of tasks related to increasing productivity, production quality, sustainability and flexibility of the production process and reducing the cycle of birth to the idea until the product is marketed.

The aim is to build a database of the modules of structural and technological design of the automated system "MICROSYS" and to determine the cost-effectiveness of its implementation in companies in the industry for the production and design of microcomponents and microtechnical products.

2. Exposure

The developed database (BD) of the MICROSYS system, as a product innovation in the market of goods and services, is a new software product that facilitates the work of designers of micromechanical components (MMC), users of these components and for student education in Microtechnology (MT). Through it, we achieve intellectualization of work, improvement of the working environment, improvement of the educational level and culture, fuller satisfaction of needs and, as a result, raising the standard of living.

Microsystem Technology (MCT) is one of the fastest developing modern technical fields, defining the development of human civilization and changing the appearance of the products and lifestyle of humanity as a whole. Computer-Aided Design (CAD) is an integral part of engineering, and microtechnology is no exception. It draws on the experience gained in microelectronics and human knowledge so far. The features of micro-products are determined by their size and production methods and determine the requirements placed on computer-aided design tools in the field of microtechnology [2].

When choosing an automated design method for MMCs, the methods for their production and operation are taken into account. Generally, group technologies are used to produce microsystems. When such technologies are applied, a large number of elements are simultaneously processed, with manual intervention being unnecessary or negligible. Used production equipment is expensive because high accuracy requirements are imposed. It is economically advantageous to produce MMCs and MMEs in large quantities. Microsystem technology is unsuitable for production of prototypes because it violates the mass production scheme by group technology. Unlike traditional systems, the microsystems ability to repair is limited. Therefore, the main goal in development is to get a fully functioning system upon first implementation. The development in the production of microsystems is in the direction of reducing the cost of materials and equipment, the amount of technological operations and improving their functional properties (accuracy, operating range, sensitivity, etc.) while increasing reliability. With the increasing complexity of microsystems, the design phase takes on an increasingly important role in the manufacturing process [3]. The developed automated system "MICROSYS" covers all stages of design - geometric modeling,

engineering analysis and determination of technological process for production. The object of design is the micromechanical functional elements, which are the smallest units of the microsystems [4].

The economic interpretation of the principle of rationality is called the "principle of economic efficiency". It requires the best possible ratio (optimal correlation) between the economic variables "output factors" and "output". Its successful implementation depends on the knowledge available (on the information available) and on the determination to take the risk.

The problems of the information resource and its new role in management have been significantly developed in a market economy due to changes in the products produced, in the production and economic processes, in the business environment, in the complication of relations with customers, competitors and counterparties, in the implementation of the information resource, the achievements of scientific and technical progress in manufacturing. Under these conditions, problems arise more quickly and intensively, exert their positive or negative influence more strongly, and therefore require timely reaction by the management of the enterprise if it does not want them to have a detrimental effect on its production and economic activity. The timely receipt of the necessary information resource at the right place and at the right time for decision-making allows not only to correctly and competently solve current production and economic issues, but also allows to predict the future development, prospects of the managed enterprise (company, organization). This place of information resource in management determines its exceptional role and importance in the development of the economy and its structural units [5].

In today's globalization environment, innovation is a major factor in enhancing the competitiveness of the company. The survival of a business organization depends on its ability to create and develop new products, to introduce new technologies, to new organization of production, to new methods of management and to entering new markets.

The creation of new goods and services poses to the trade the problem of seeking new directions and opportunities for realization of these goods and services. One such novelty is the database of the MMC Computer-Aided Design system for the microsystem products "MICROSYS".

The positive economic and social impact of the use of MTs is to increase labor productivity, create new industries and jobs, improve the service sector and increase the competitiveness of goods and services globally, stabilize prices and reduce trade, deficit, stabilization of the exchange rate of the national currency, intellectualization of labor, improvement of working conditions, improvement of the educational level and culture, meeting the needs more fully and, as a result, raising the standard of living.

Product and technological innovation are closely linked. The market can trigger a new product concept, and it can in turn trigger a new technical or technological concept. The manufacturing requirements give birth to a new technological concept in which new products can emerge [6].

The innovation process is a lengthy one and carries a high risk, facing many barriers. It is therefore necessary to structure it into phases:

- Product and technological innovation are closely linked. The market can trigger a new product concept, and it can in turn trigger a new technical or technological concept. The manufacturing requirements give birth to a new

technological concept in which new products can emerge [5]. The innovation process is a lengthy one and carries a high risk, facing many barriers. It is therefore necessary to structure it into phases;

- Creating an idea for innovation;
- Finding a scientific solution - basic and applied research;
- Finding a technical solution - applied idea development, development activity;
- Introduction of technology or product - preparation of production, introduction of the product on the market;
- Diffusion of a new technology or product.

MT, considered as an innovation, involves the greatest use of new ideas, processes, goods, services and practices. It is also more or less a commercial method, the basis of which is the application of science and / or technology in the implementation of various production processes. This is a kind of engine of positive development [10]. There is one of the decisive factors in human progress. There are many definitions for the nature of innovation. All of them can be grouped in two directions:

- Innovation is seen as a continuous creative process, as an innovative activity, a continuous renewal of the creative process of creating and realizing a new style;
- Innovation is seen as a integrative integrative process that encompasses creation, design, implementation, adaptation and utilization.

When it comes to innovation, the concept is associated with something progressive and positive. So is the CAD system "MICROSYS".

A structural scheme and database of the specialized system for automated design of MMC and selection of technological process for them "MICROSYS" was designed and developed. The system is built on a modular principle with possibilities for detailing, local optimization and verification of the obtained results. It is a product innovation and is a new product globally, new to the consumer and the manufacturer, and implies the creation of a new market. Through it we achieve intellectualization of work, improvement of working conditions, improvement of educational level and culture, fuller satisfaction of needs.

MMEs and MMCs are made on the basis of the main technologies used in MT (deposition of layers on a substrate or a previous layer, methods for applying thin layers, methods for applying thick layers - screen printing, methods for coating and modifying and surface layer structuring - modification methods, microstructuring methods by lithography, etching, LIGA method, microstructuring methods by mechanical micro processing; high energy sources processing methods - electron treatment n beam processing with a laser beam machining, plasma jet).

Different technologies are used for different types of MMEs and MMCs and are classified according to different characteristics. The production price must be analyzed, valued and qualified for investment - this is the purpose of the author of this development.

The production price of MMEs and MMCs is calculated using different price factors:

- Investment price (investment, investment capital);
- Maintenance, technical operation;
- Raw materials and materials (cost of materials - substrate, layer layering, supporting part of integrated circuits, etc.);
- Additional prices of materials and raw materials;
- Cost of production (labor, wages, insurance, etc.).

Price factors are developed and determined by the economy, but they also determine the production process.

$$C_{\text{total}} = \sum (C_{\text{mi}} + C_{\text{wi}}) (A_{\text{ci}} / A_{\text{wi}}) + n_p \cdot C_p + C_h,$$

at $i = 1$ to N .

Where:

C_{total} is the full price, BGN;

C_{mi} - price of the main materials (on the pad), BGN;

C_{wi} - the cost of layering the layers on the pad (from 200 to 1000 €, depending on the technology), BGN;

A_{wi} - layered area (usable area), μm^2 ;

A_{ci} - chip area (different for different functions), μm^2 ;

C_p - package prices per piece (0,01 € per item), BGN;

n_p - number (standard);

C_h - housing or case costs, BGN.

A price formula for a silicon (Si) sensor obtained using microtechnology (MT) has been defined.

In the Table 1 the parameters for a silicon (Si) microcomponent based on a monolithic integrated circuit are presented.

Table 1

Material	Specific weight, [g/cm ³]	E-modulus of elasticity, [10 ³ N/mm ²]	Thermal expansion, [10 ⁻⁶ /K]	Thermal conductivity, [W/Km]	Price for 150 mm wafer, [€]
Silicon	2,3	190	2,33	157	30 - 50
Al ₂ O ₃	2,5	73	0,55	1,4	2 - 15
Glass	2,2		3 ... 10	1,1	30 - 50
Steel	7,9	210	12	97	< 0,50
Al	2,7	70	25	236	< 0,50

Let's look at the following example of an electronic Si sensor shown in Table 2 and Table 3 as in Fig. 1 and Fig. 2:

Table 2

Technology	Layers	Costs per wafer
CMOS layering	16	500 €
Si basis	8	250 €
Additional CMOS layers	24	750 €
CMOS layering on 2 surfaces	18	600 €

Table 3

Paragraph (parameter)	Value	Unit of measure
A_c	10	mm ²
A_w	15000	mm ²
n_p	20	piece
C_p	0.01	€

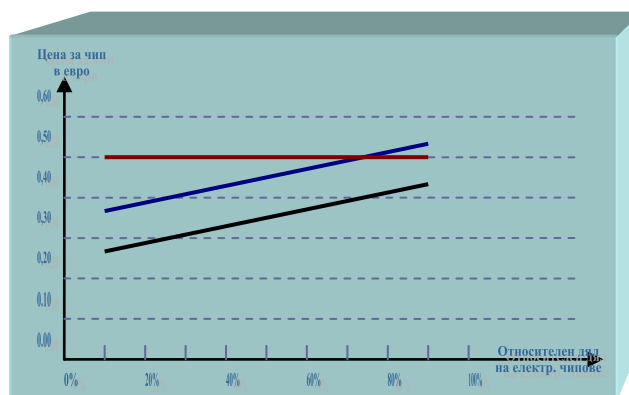


Fig. 1 Different MMEs with $A_c = 10 \text{ mm}^2$



Fig. 2 Different MMEs with $A_c = 50 \text{ mm}^2$

Table 4

Technology	Price per layer [€ cent/mm ²]	Note
CMOS	5 - 10	12 - 18 layers
Thin film mirror	3 - 5	max 6 layers
Surface micromechanical electro-optical thin film	2 - 4	max 6 layers
LIGA	> 100	in an electronic acceleration apparatus

Microsensors require a very small A_{ci} - chip area (different for different functions), actuators require $A_{ci} = 100 \text{ mm}^2$, etc. these data are presented in Table 5:

Table 5

Mechanisms MMEs, MMCs, actuators, sensors	Chip size [mm ²]	Size of the surface [μm]	Manufacturing technology, application	Investment, level	Volume of production, level
Precise mechanisms	> 100	10	Batch production of mechanisms	Low	Low
Actuators, fluid, optical, mechanical	> 10	2	Wide field of application	Average	Medium to High
Integrated electronic microsystems, sensors	< 10	< 1	Layering	High	High

The factory price (production) is directly influenced by the A_{ci} – chip area (different for different functions) and the investment in production and it is different for different MMEs, MMCs, sensors, actuators. This is illustrated in Fig. 1 and Fig. 2, as you do different colors for different MMCs.

3. Conclusions

The positive economic and social impact of the use of MTs is to increase labor productivity, create new industries and jobs, improve the service sector and increase the competitiveness of goods and services globally, stabilize prices and reduce trade,

deficit, stabilization of the exchange rate of the national currency, intellectualization of labor, improvement of working conditions, increase of educational level and culture, fuller satisfaction of needs and, as a result, raising the standard of living [9].

The developed database of the MICROSYS system is a product innovation. It is a new product globally, new to the consumer and the manufacturer, creating a new market. The role of innovation for economic development and prosperity for each country, company and organization for its competitiveness on the international market is enormous. MT, considered as an innovation, involves the greatest use of new ideas, processes, goods, services and practices. It is also a more or less commercial way, the basis of which is the application of science and / or technology in the implementation of various production processes. This is a kind of engine of positive development. There are one of the decisive factors in human progress.

The efficiency of any production is a prerequisite for economic and social progress. It is economic efficiency that motivates every business activity. This is also one of the main distinguishing features of a centrally planned market-oriented economic system. In a market economy, competition between producers, as well as the legal macro-framework in which the business operates, require firms to use the limited production resources as efficiently as possible. As a rule, economic efficiency is not uniquely measured, but is considered and evaluated at different levels - investment efficiency, production efficiency, R&D efficiency, efficiency of the enterprise as a whole. Different criteria and indicators for analysis and evaluation are to be used [8].

It should be noted that the importance of cost-effectiveness is determined by:

- its measurement on the basis of the general statement in the economy - input and output, i.e. what is invested and what is received;
- assessment of the use of inputs, financial and labor resources;
- an assessment of the state of the company in comparison with previous periods and other companies in the industry on the basis of calculated indicators.

A price formula for a silicon (Si) sensor obtained using microtechnology (MT) has been defined.

The effect of DB implementation is to reduce production costs and design time, which will reduce the cost of the product. This necessitates a production-technological analysis and a strategy for the further activity and development of the project: Automated system for structural and technological design of MC and products from the micro-technology "MICROSYS".

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Analytical study of family business in Bulgaria

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Abstract: On a global scale, family businesses are considered to be a key element of the local and national economy. The role and importance of family business stems from the fact that this business is an important source of economic growth and prosperity. It makes an important contribution to the formation of gross domestic product. At the same time, family business contributes significantly to employment growth and job creation. In addition, this business contributes to the socio-economic and social development of the local, regional and national level of the country. In addition, it is important to emphasize that the role and importance of the family business is also determined by the fact that it is regarded as an essential basis for training entrepreneurs. This importance is due to the fact that the family business develops an entrepreneurial spirit and a new business culture. As a result of the analytical study of the nature and characteristics of the family business in the country, recommendations and guidelines for its promotion have been presented.

KEYWORDS: INNOVATIVE ACTIVITY, FAMILY BUSINESS, HOME BUSINESS

I. Analytical nature of the family business

A family business is considered to be a business where more than 51% of the property is in the hands of the family. But individual family businesses also have different characteristics in terms of ownership, control, family-business interaction and management transfer. In 2009, The EC adopts a single European definition of family business. According to this definition, a company, regardless of its size, can be categorized as a family business when it meets any of the following conditions:

- the majority of votes in the governing body is the property of the natural person (s) who created the company or of the person (s) who acquired the share capital of the company or their spouses, parents, children or the direct heirs of their children;
- the majority of the votes in the governing body are directly or indirectly controlled;
- at least one representative of the family is officially involved in the management of the company;
- companies whose shares are traded on the stock exchange meet the definition of a family business if the person who founded or acquired the company (its share capital) or his family / heirs holds 25% of the votes in the governing body, based on their share of the capital of the company [3,4,5,6,11].

Each of the above definitions addresses the three elements of family engagement in different degrees or in different contexts: degree of ownership, degree of family involvement in business management, and the potential for intergenerational transfer of power.

II. Determining the Identity Points for Success in the Family Business.

The key characteristics of a family business are a direct result and effect of family involvement. Family involvement and family relationships shape the values of family business, culture and organizational structure. This means that key characteristics can have a positive or negative impact, depending on how family relationships work in business [1,2,8].

In this context, the benefits of a family business include:

- shared values and beliefs - The family imparts its core values and beliefs to the business by offering a clear identity and a clear mission. This set of unique, hard-to-imitate values and beliefs helps the family business create competitive advantage, identify hard-to-take away skills and competencies, and establish initial management rules;
- shared goals - family members directly involved in the family business make a significant investment in the business. This investment is not only financial but also related to employment, inheritance, family name and social status. Therefore, the success of the family business is a common goal and offers considerable motivation for cooperation and hard work;
- family spirit - family businesses rely on the biological link between their members to overcome crises, promote family unity, create and strengthen a unique competitive advantage. Family heritage and traditions give courage to younger generations to understand and overcome difficulties, creating mechanisms for business sustainability;

- Family name - The family name of a successful family business provides benefits such as confidence, trust, quality and personal commitment. This means that the family name is a source of pride and creates corresponding responsibilities;

- Organizational effectiveness - It is achieved if managers work to satisfy the interests and goals of the owners. In effective family-business relationships, the dual identities of family members minimize the possible risks of separation of ownership from management. At the same time, decision-making can be more expeditious and flexible;

- Flexibility - The informal nature of family relationships makes it possible to limit hierarchical and bureaucratic decision-making and control mechanisms. This offers a unique competitive advantage over non-family businesses, as strategic decision-making can be quicker and immediate;

- Long-term commitment - Family members are dedicated to the long-term family business. Their investment in business is financial and sentimental, allowing otherwise irrational employment decisions to be made for certain individuals. Long-term commitment also means that family members do not expect immediate financial returns and can accept lower salaries or other short-term benefits in exchange for support for the family business;

- Economic independence - Family members have considerable economic independence while working for the family business. Salaries, profit sharing, and capital increases are targeted at the same persons;

- Entrepreneurial culture - The entrepreneur (s) who founded the family business feed it with an entrepreneurial culture and encourage family members to think and act entrepreneurially. This encourages innovation, the identification of opportunities, the generation of ideas, risk-taking, creative problem-solving and entrepreneurial flexibility.

The main disadvantages related to family involvement that family businesses have compared to the non-family business include:

- Family conflicts - Personal differences, family disputes, brotherly rivalries and inter-generational differences often lead to conflicts. Family-related conflict has long undermined the family business and led to unwanted behavior, misunderstandings, poor results and conflict of goals. Subsequently, this may result in the failure of the family business or the termination of family partnerships. In addition, family conflict discourages key non-family stakeholders (investors, consultants, employees and key partners) from engaging in the family business [4,9,10];

- Problems related to the establishment of borders - Such problems arise when family members fail to sufficiently differentiate between family life and business;

- Role intertwining - Another effect of family involvement is the difficulty of drawing the dividing line between owner and manager. There may be misunderstandings about "Who's doing what?" And the separation of duties and responsibilities, which will adversely affect communication and decision-making. At the same time, supervising and criticizing relatives can be challenging for family relationships;

- Lack of objectivity - Work in the family business and related career development is in most cases based on subjective

decisions. This is not necessarily a mistake, as there are some positives associated with hiring family members to work in the family business. However, this lack of objectivity may not be the result of business-focused decisions but of family-related processes. For example, hiring younger family members at lower wages, offering higher wages to certain family members, or raising the position of more distant relatives to have peace with older family members may prevent business growth;

- Nepotism - Career development based on family relationships rather than qualifications is often demotivating for non-family employees [11].

III. The family business in Bulgaria

In Bulgaria, family business is perceived as small-scale, i.e. mainly represented by micro-enterprises in sectors such as agriculture, services, tourism, retail, crafts and more [1,2]. The family business makes up about 42% of all private Bulgarian companies. They provide nearly 20% of value added to the country's GDP and about one-third of jobs. Of these, nearly 43% are in the services sector, nearly 38% are in the trade sector, 15% are in the manufacturing sector and 4% in the construction sector (Figure 1).

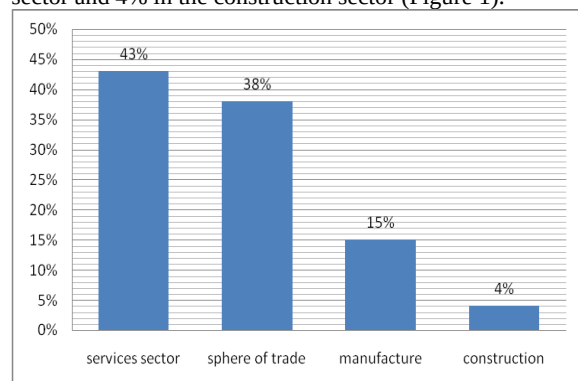


Figure 1 Distribution of family business by sectors [3]

In 2019, the number of employed persons in the family business is 399,414. The results of the study done for the needs of this publication show that in the trade sector- automobile and motorcycle repairs are employed by 31.3% of persons employed in family enterprises, in the manufacturing sector - 27.0%, in the hotel and restaurant sector - 7.2%, and in the construction sector - 6.8%. The share of employees in the family business is the largest in the Southwest region (31.3%). In the South-Central region it is 20.5%, in the Southeast - 14.9%, in the Northeast - 13.3%, in the North-Central - 11.1%, and in the Northwest - 8.8%. The number of employed persons in the family business is largest in the Southwestern region (124,815 enterprises) and the smallest in the Northwestern region (35,175).

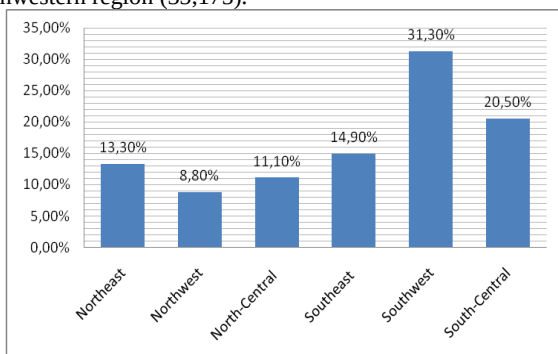


Figure 2. Distribution of employees in the family business by statistical regions [3]

Age structure of entrepreneurship is indicative of a strong presence in the SME sector of the representatives of the age group 40-49 years, lower presence of younger entrepreneurs up to 29 years (5%) and 22% among the age group of 30-39 years. This structure signals potential risks to the sustainability of the sector: in the short term (up to 5 years), 15% of SMEs will face problems related to business

transfer from the older generation to the younger generation; and in the medium to long term (up to 15 years), a total of over 38% of enterprises (or every two out of five enterprises) will face these problems. These demographic processes in the SME sector are also related to the demographic trends affecting the population in Bulgaria (which also have their regional dimensions). Although a large number of SMEs are likely to successfully solve the problems of handing over the business to the younger, it is not clear what proportion of businesses will start their business (Figure 3).

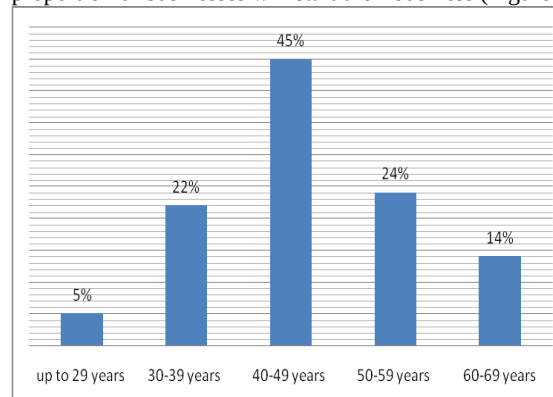


Figure 3 Age distribution of entrepreneurs in the sector [3]

Almost 70% of Bulgarian family businesses are still managed by their founder. In about 12% of family businesses, inheritance has already taken place; 8.6% of companies plan to transfer management to an heir in the near future (up to 1-2 years), and about 11% plan to do so in the medium term (3-5 years). Over 61% of companies will not transfer management to an heir in the next 10 years, and nearly 12% of companies plan to transfer management control in 6-10 years.

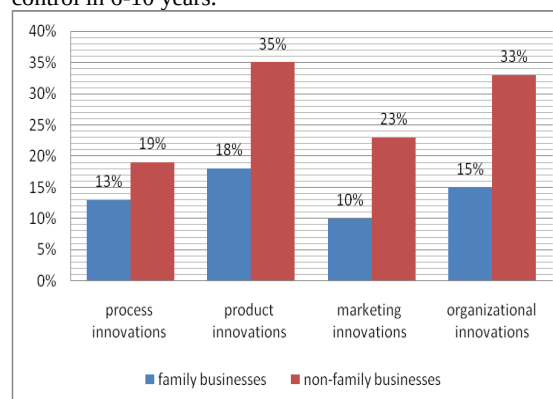


Figure 4 Innovative activity of family and non-family enterprises [3]

Figure 4 illustrates the innovative activity of family and non-family businesses in 2019. The result of the study shows that 13% of family businesses have made process innovations, and in non-family businesses this activity is 19%. 35% of non-family businesses have introduced product innovations, while in the family business they are 18%. 10% of family businesses have implemented marketing and 15% of organizational innovations. In contrast, in non-family businesses, activity is relevant for marketing - 23% and for organizational innovations - 33%

Most Bulgarian family businesses do not plan important activities and aspects related to the transfer of ownership and management control to the next generation. Less than 17% of family businesses have prepared a plan to transfer management control to an heir. A list of potential heirs made up less than a third (29.7%) of family businesses. The highest share of companies providing training to potential heirs is 42.4%. A business plan after transferring management control to an heir has been developed by less than 15% of family businesses. A quarter of the family-owned companies have decided how the property will be distributed after transferring management control of the business to the heir.

Table 1. Inheritance planning in Bulgarian family businesses [3]

An unwritten plan for transferring management control of the business to the heir (s);	17%
List of potential business successors;	30%
Training of potential heirs for their future role in business;	42%
Business plan after transfer of management control to the heir (s);	14%
Decision how ownership will be distributed after transferring management control over the business to the heir (s).	25%

IV. Output of identical success points.

- adoption of a legal definition of family business;
- promoting research on family business in Bulgaria, as there is a lack of systematic and detailed statistics related to the characteristics of this business;
- support for the establishment of representative structures of the Bulgarian family business that will contribute to its sustainable future development;
- promoting the establishment and maintenance of family business networks, in which the participation of universities, research organizations, consultants and others is advisable;
- it is advisable to take priority in the development of small and medium-sized enterprises policy;
- promoting the transfer of family businesses;
- promoting education, training and consulting in family business management;
- improving the image and promoting the values of the family business. It is summarized that in addition to the above recommendations, which are fully applicable to the family business, it is necessary to make such recommendations as:
 - creating the necessary conditions for businesses to participate in the various schemes of European business promotion programs;
 - increasing the cost of R&D of the existing family business;
 - improving the qualifications of owners and managers in terms of effective implementation of innovation and investment activities;
 - increasing the number of highly qualified professionals who can carry out innovation and research, including through training of company staff;

- stimulating the introduction of different types of innovation (marketing, new markets, organizational, product, process, technological);
- increasing the number of enterprises cooperating with each other;
- pursuing a purposeful state policy combined with the assistance of branch and regional institutions and organizations in support of the family business.

V. Conclusion:

Based on an analytical study of the state of the family business, it can be concluded that the family business contains significant reserves of success. However, this requires the development of a long-term program, based on the priority of the individual points of success.

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The conception “Balanced Scorecard” - tool for strategic management of higher education institutions

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Abstract: The paper deals with the conception of Balanced Scorecard (BSC) as an innovation strategic management system, which appears to be a superstructure of the Quality Management Systems and provides for the assessment of the basic processes in an organization. The BSC methodology and its relationship with the ISO 9001 requirements is presented and on this basis, an innovation strategy map serving the purposes of a university development has been developed.

KEYWORDS: BALANCED SCORECARD, STRATEGY, INNOVATION, MISSION, PURPOSES, MEASUREMENT

1. Introduction

The development of society at this stage is knowledge-based, from which it follows that only structures that create, develop and evaluate knowledge can be considered successful. Moreover, the industry in the so-developed economies are already transforming from processing raw materials into processing information into knowledge and innovation. This trend in the development of society and the economy is called the "third wave". This means that industrialized economies in the world are already transforming into organizational structures based on information and knowledge [1].

With the entry into the stage of the fourth technical revolution and increasing the requirements for the qualification and skills of the company staff, more and more attention will be paid to the technical and organizational aspects of personnel training for these intelligent industries. This technical development becomes a top priority for many research centers, universities and companies in recent years with numerous contributions from scientists and practitioners. [2]

The higher education in our country is changing constantly. The new normative documents and the increasing rivalry require effective and efficient management, which in turn needs innovation modern tools. Each university faces the necessity for constant enhancement of its competitive power at both national and international level [3, 4]. All this could be achieved by well-developed and effective management systems. Figure 1 shows Management subsystem integration. The most extensively developed systems comply with the requirements of ISO 9001 [5]. The application of Balanced Scorecard (BSC) has been rather scanty in this country so far. For this reason, the main purpose of the paper is to popularize the conception of Balanced Scorecard as a tool for university management and development.

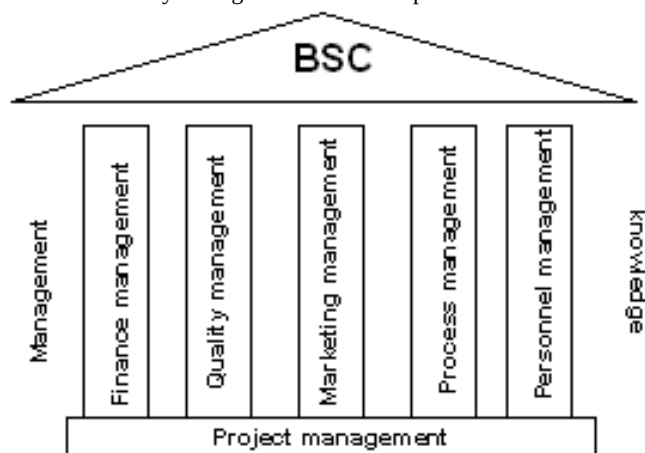


Fig.1. Management subsystem integration

2. Relationship between BSC and the ISO 9001:2015 requirements

BSC constituents are closely related to ISO 9001:2015 concerning the Quality Management System in an Organization. The close correspondence between the requirements of the standard and those of BSC will be analysed in details below.

2.1. Preconditions and means for resolving the problem

The requirements to the top management can be found in ISO 9001:2015, Section 5.1 Leadership and commitment are as follows: “Top management shall demonstrate leadership and commitment with respect to the quality management system by: taking the accountability for the effectiveness of the quality management system, ensuring that the quality policy and quality objectives are established for the quality management system and are compatible with the context and strategic direction of the organisation, ensuring the integration of the quality management system requirements into organisation’s business process, promoting the use of the process approach and risk-based thinking, ensuring that the resources needed for the quality management system are available, communicating the importance of effective quality management and conforming to the quality management system requirements, ensuring that the quality management system achieves its intended results, engaging directing and supporting persons to contribute to the effectiveness of the quality management system, promoting improvements, supporting the other relevant roles to demonstrate their leadership as it applies to their areas of responsibility.

A policy and mission following the strategic priorities of the organization in terms of quality should be developed. As a rule, this document is mandatory and serves as a tool for the formal delineation of the trends in the organization quality development. Thus, the BSC basic principle of organization strategy formulation is also considered in the ISO standard with the only difference that the organization development strategy in the form of a policy is implemented only in ensuring quality [6].

2.2. Co-ordination of the strategy with the subdivision tasks and individual goals of the employees

Section 5.2 “Quality policy” states that “Top management shall establish, implement and maintain a quality policy that: is appropriate to the purpose and context of the organization and support its strategic directions, provides a framework for setting the quality objectives, include a commitment to satisfy applicable requirements, include a commitment to continual improvement of the quality management system.”

Section 5.3 “Top management shall ensure that the responsibilities and authorities for relevant roles are assigned, communicated and understood within the organization.

Top management shall assign the responsibility and authority for: ensuring that the quality management system conforms to the requirements of this International Standard, ensuring that the processes are delivering their intended outputs [7], reporting on the performance of the quality management system and on opportunities for improvement, in particular to top management, ensuring the promotion of customer focus throughout the organization, ensuring that the integrity of the quality management system is maintained when changes to the quality management system are planned and implemented.

Quality objectives and planning to achieve are described in Section 6.2

The organization shall establish quality objectives at relevant functions, levels and processes needed for the quality management system.

The quality objectives shall: be consistent with the quality policy, be measurable, take into account applicable requirements, be relevant to conformity of products and services and to enhancement of customer satisfaction, be monitored, be communicated, be updated as appropriate.

The organization shall maintain documented information on the quality objectives [8].

When planning how to achieve its quality objectives, the organization shall determine: what will be done, what resources will be required, who will be responsible, when it will be completed, how the results will be evaluated.

Quality objectives and roles should be created on the basis of the policy (the quality development strategy). These are particular tasks (actions) which should be fulfilled in order to put the strategy into practice. The objectives should be quantitative in nature, i.e. they should contain performance indicators (in numeric values) which make the assessment of quality policy implementation possible.

Objectives for the particular subdivisions should also be developed, their compliance with the organization objectives being ensured. The availability of such a system of performance indicators will make the analysis of the correspondence of the actions undertaken within the quality objectives to the organization strategy tasks possible.

The ISO 9001: 2015 requirements are compatible with the BSC principles in the following:

- Organization strategy development is carried out by the organization managers or owners on the basis of the measurable indicators (quotients);
- The organization development strategy should be expressed in real measurable objectives which, in turn, should be implemented at the departments level.

2.3. Elucidation of the strategy to the employees in the organization and establishing of feedback for organization strategy correction.

Section 7.3. "Awareness" comprises the following requirements: The organization shall ensure that persons doing work under the organization's control are aware of: the quality policy, relevant quality objectives, their contribution to the effectiveness of the quality management system, including the benefits of improved performance, the implications of not conforming with the quality management system requirements.

The „communication" following requirements:

The organization shall determine the internal and external communications relevant to the quality management system, including: on what it will communicate, when to communicate, with whom to communicate, how to communicate, who communicates.

As stated earlier, the quality policy should correspond to the organization objectives. The employees should be informed about the quality policy and objectives in terms of documentation indicating the strategic trend of development by means of the internal communication system which should be convenient enough

to be used. BSC also stipulates a procedure for establishing communication between the employees giving them an opportunity for obtaining the information necessary for undertaking corrective actions in terms of organization strategy which is in complete compliance with the ISO 9001:2015 requirements.

2.4. Periodic and systematic review of the organization strategy

Section 9.3 "Management Review" stipulates the following: "Top management shall review the organization's quality management system, at planned intervals, to ensure its continuing suitability, adequacy, effectiveness and alignment with the strategic direction of the organization."

Top management review shall consider the quality policy and quality objectives compatibility with the modern organization needs, as well as with the degree of achievement of the pre-determined quality objectives at all organization levels.

BSC, as well as the ISO 9001:2015 standard, stipulates a recurrent review of the efficiency of the quality management system when spreading the organization strategy out to particular levels. In this case, both methods use numerical values as a basis for their analysis. Another element common for both systems is the existence of a system of documentation hierarchy.

The unfolding of the objectives in BSC is carried out by means of:

- Strategy maps logically connected with the strategic objectives
- Balanced indicators map (which quantitatively measure the business processes effectiveness, results and deadlines);
- Projects (investment, training, etc.);
- "Templates" of parents at different levels for control and assessment of the performance.

The ISO 9001:2015 standard, in turn, suggests a system of documentation hierarchy of its own.

- Quality policy and quality objectives, a reference book on quality;
- Procedures;
- Processes maps;
- Instructions, specifications, organization documentation;
- Quality records.

As can be seen, both BSC and the ISO 9001:2015 standard employ similar formal tools for organization strategy recording and realizing (documentation hierarchy), providing information channels among particular structural subdivisions and employees within the organization and introducing improvements in the system. The data about the system concern diverse areas (with ISO 9001:2015 this area is limited mainly to quality management, whereas with BSC it is much broader involving the strategic development of all activities of the organization). These areas are directed to organization efficiency involving maximum customer satisfaction resulting from the achievement of the predetermined goals.

Regardless of the great number of shared requirements between the two systems, the single implementation of a Quality Management System is insufficient to support the strategic management of a university. The reasons for this are as follows [9, 10, 11].

- The ISO approach accentuates upon the processes management and not upon the real factors influencing the object of training itself, i.e. the students, their aptitude and motivation.
- The ISO approach is not by all means connected with the results of the education condition analysis. This approach is universal; it is relevant for all fields and such an analysis is not necessary for its implementation. Therefore, it does not show the specific and sometimes crucial factors influencing quality. The approach is not expected to show the means of quality increase and which means are to be included in the Quality Management System

itself. The most important issue with this approach is that “the folders are in the correct order”.

- The ISO approach is based on the assumption that the customer (the student) is interested to the greatest extent in the high quality of the product and the organization-producer should provide him/her with this product. Nowadays, however, this assumption appears to be irrelevant. A student just does not purchase educational service as a ready-made product (as opposed to the customer in industry and commerce) but obtains it due to his/her own intellectual efforts. Thus, the student turns to be one of the real “manufacturers” of the product.

Unlike other areas where the customer is outside the system providing the product which he/she purchases, the student is inside the system, being its active element. Although the customer is in the focus of the ISO standard, the analysis of the systems implemented in some universities shows that the student is not explicitly present in these university systems [9, 11].

The ISO approach requires the establishment of the following:

- standards to be observed at the university in order to achieve the desired quality, concerning curriculum and particular subject design, knowledge modelling and the interaction between faculty and students
- ways of creating a students’ system of values in such a way that they strive for high quality and for learning how to self-educate themselves
- ways of motivating students for setting higher standards and goals to themselves during their study at university
- methods of students’ knowledge and skills assessment and their gradation.

3. The essence of BSC

BSC is one of the tools for business processes controlling. The essence of BSC is measurability. “All factors which are important for the company management should be measured; what cannot be measured, it cannot be managed.” [12]. The idea of a balanced system of indicators, i.e. BSC, was a realization of the desire of the management to be provided with a set of financial and non-financial indicators for intra-organizational management goals.

BSC transforms the mission and general organization strategy into a system of clearly stated tasks and objectives, as well as indicators determining the degree of objectives achievement, hierarchically grouped into four perspectives, i.e. “Financial”, “Customer”, “Internal Processes” and “Infrastructure/ Employees”. It is shown in Fig. 2. This gives answers to four of the most important issues in an enterprise concerning standard perspectives and the analysis of the goals of each of these perspectives allows for the answer to the following basic questions:

The Financial Perspective: shareholders’ expectations. “How will the strategy influence the financial state of the company? How does the organization appear to its shareholders and potential investors?”

The Customer Perspective: customer’s expectations. “How are we positioned in the intended markets? How does the organization appear to its customers?”

The Process Perspective: the process requirements. “Which are the strategically important processes? Which business processes should the organization focus on and improve?”

The Learning and Growth Perspective: growth and innovations requirements. “In what way should we become a constantly training organization? How do we stimulate growth? What resources will help the organization continue to grow and increase its business effectiveness?”

The BSC implementation is possible when the strong and weak points and the market situation are identified in the organization and on this basis the mission and strategic priorities for organization growth are established. The process of BSC introduction is accomplished in the following three steps:

1. Formulation of objectives whose achievement leads to mission and strategy realization (balance).

2. Creation of indicators with the help of which the level of achievement of each objective and the efficiency of actions providing the desired indicator level (cascading) is measured.

3. BSC implementation and activities.



Fig. 2. Balanced scorecard

Starting from the top and spreading downwards over all four perspectives “Financial”, “Customer”, “Internal Processes” and “Infrastructure/ Employees”, are arranged the objectives whose achievement facilitates strategy and mission realization. It is only the new objectives supporting the achievement of the existing ones that are written on the map. To focus attention upon the aspects involved in the mission and strategic priorities, it is recommended that the number of objectives does not exceed 25. For more detailed representation of tasks and objectives, a set of supplement maps of “second level” may be created. This level contains a map provided for each strategic priority or for each particular strategic unit in the organization. Figure 3 shows the hierarchic level development of BSC.

The qualitative and quantitative distribution of the objectives by perspective is the following:

- “Financial” – objectives revealing the ways of achieving the strategic intentions in the field of finance (3-5 objectives);
- “Customer” – objectives describing the market situation and strategy as a way of achieving the financial objectives at the previous level (5-6 objectives);
- “Internal processes” – objectives describing the directions on which efforts should be concentrated as a way of achieving the objectives of the Customer Perspective and Financial Perspective (6-10 objectives);
- “Infrastructure/ Employees” – objectives describing the ways of achieving a particular condition of the assets as resources for achieving the internal processes objectives (4-6 objectives).

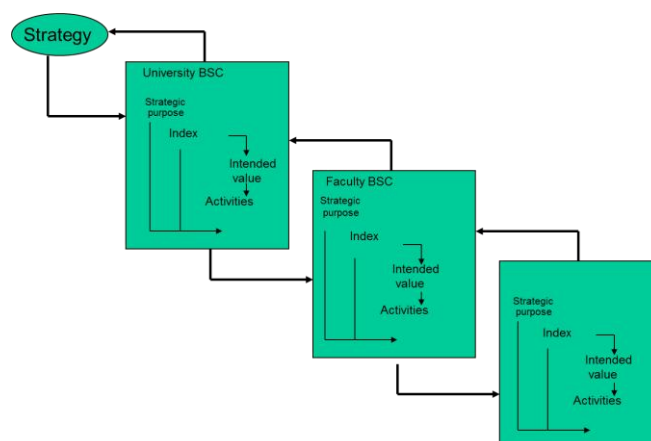


Fig. 3. BSC hierarchic level development

A strategy map should be balanced by the vertical axis, i.e. the achievement of the objectives at lower levels should facilitate the achievement of those at higher levels. There should not be an

objective which does not support other objectives at the same or lower level, with the exception of those at level 4. There should not be objectives which do not support objectives at the same or higher level except for some objectives at level 1.

At the second stage indicators are developed with the help of which the level of achievement of each objective is measured and actions which are to provide the required level of the indicator (cascading) are planned. It is recommended that a set of indicators incorporating both performance indicators and forming indicators should be developed for each of the objectives. The former characterize the degree to which a particular objective has been achieved and the latter show the efforts for its achievement.

The objectives map should also be balanced by the horizontal axis. Therefore, causal relationships between the performance and forming indicators should be determined within each set of indicators. After that, a complex of actions is developed with the help of which the objectives achievement is planned. On the one hand, one action may facilitate the achievement of several objectives and on the other, several actions may facilitate the achievement of a single objective. The deadlines, means and the subdivisions and people responsible for each action are determined.

Should there be objectives which are not supported by other objectives or for which indicators and actions are difficult to be developed, it is necessary either to analyse the causal relationships, to paraphrase the objectives or even to exclude them from the number of objectives to be achieved.

Further, the indicators are projected upon the organization structure, thus the complex of indicators being decomposed, responsibilities being distributed, the process of collecting the indicators and the sources of information at lower levels of planning, as well as the feedback for each indicator and level of automation of these processes being determined.

The third stage is that of BSC implementation in the operational performance. At this stage the following actions are undertaken:

- development and realization of the action plan for BSC implementation;
- training in the principles of operation of BSC;
- control of the action realization;
- indicator monitoring;
- synchronization of BSC with the motivation system;
- synchronization of BSC with the existing systems for organization reporting and management.

The efficiency of BSC in the organization depends directly on the extent to which it is implemented.

Based on the mission, strategic priorities and the analysis of the internal and external environment at a university in compliance with the methodology of BSC, a map of the objectives of BSC has been developed representing the mission and the strategic priorities of a university from the point of view of the four perspectives given in Fig. 4.

4. Conclusions

The paper presents a comparative analysis between the requirements of a Quality Management System and BSC. The conclusion that may be drawn is that there are shortcomings in the implementation merely of Quality Management Systems or BSC and that a strategy map development is of vital importance for a university.

What does BSC provide us with in terms of tertiary education:

- An exhaustive and deep evaluation of the condition and the perspective for development of a university;
- BSC becomes a language and creates an environment for communicating ideas within the education institution, at the same time appearing to be the core of knowledge in the university;
- BSC is not only a means of analysis but a means of objectives achievement;
- BSC provides for the rapid adaptation to the changing environment.

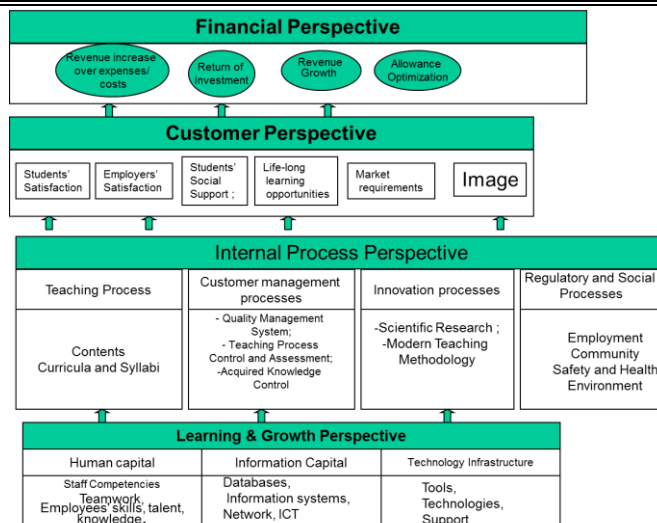


Fig. 4. Strategy map

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Intellectual Property Rights (patents): Essentials and innovative potential in wine industry

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Abstract: *The aim of the paper is to explore what the influence of the Intellectual Property Rights (IPRS) on the Modern economic growth is, whether there is a relationship between them, and what impact can patents have on the invention activity – positive, negative or both. It is going to explain the importance and association of technological progress with economic growth, the main goal and idea of IPRS, the way the system has been used in the period of the beginning of Modern economic growth, and research whether patents were the biggest incentive for inventors in this period as a whole and in wine industry in particular. The paper provides examples of the main European, United States and International patents available on wine production and preservation.*

KEYWORDS: INTELLECTUAL PROPERTY RIGHTS (IPRS), INVENTION, PATENT, MODERN ECONOMIC GROWTH, INNOVATION

1. Introduction

The paper presents the influence of the Intellectual Property Rights system (IPRS) on the Modern economic growth and the arguments which can be viewed in this regard. The authors claim that before making an exact final statement, it is crucial first to present the main points of views and comment them.

The **authors' thesis** is that patents indeed are a big part of the whole technological progress and, thus, economic development, but at the same time IPRS has not been the biggest incentive and influencer of the economic growth. **The main object** of the research is patents and their strong influence over the motivation of the inventor. The paper is a part of a project focused on the innovation activities made by wine industry in Bulgaria. Thus the topic suggests good practices that can be used by wine specialists.

The subject of the paper is the influence of IPRS on the innovation process. **The research aims** to derive to the final conclusion and improve our view on the ascendancy of patent law and patents themselves.

The study is structured as follows: following the introduction in the second part is described the issue of technological progress. The third part pays attention on the Intellectual Property Rights (IPR) and their importance. This analysis paves the way for the fourth part, in which is highlighted the responsibility and the right of deciding the future of the invention. The fifth paragraph provides examples of the main European, United States and International patents available on wine production and preservation. The article closes with conclusions and recommendations for future research in the field of investigation the role of intellectual property rights and their role in the wine industry.

2. Technological Progress

One of the most important prerequisites for a consistent economic growth is the technological progress. We can use as a reference argument the Malthusian theory (T. Malthus, 1959) as it states that there cannot be an infinite rise of the population as at some point the resources would not be enough for everybody, although it has nothing to do with IPRS. But there is one way we can avoid this and it is exactly what we have done in the last 200 years – progress in technology, because of which we can still live a normal life despite the formidable rise of our population since then. Similarly, but not exactly, this is the case with the direct proportional relationship between technologies and economic growth.

If there is no technological progress, economic growth will remain constant at some point. The argument to this statement is based upon the fact that technology influences production, life, business, etc. And as we know, production is on the basis of wealth. Hence, difference in productivity creates difference in wealth. One of the limited resources we have is time. The day duration stays constant and the more we produce in those hours, the more we can

consume (this is how we have managed to refute the statement of Malthus to a certain extent).

To explain the phenomenon of consistent economic growth, namely that in each year the economy produces more than it produced in the former year, Robert Solow (1956), who later received a Noble prize for his contribution, introduced technological progress into his model. The development of technology increases the supply of effective labor, because by using technology the productivity of labor increases (or at least this should be the main goal of the progress). Technology prevents the decline of marginal returns to capital.

Instead of assuming that technology automatically influences the economy for no clear reason, Solow suggested that innovation can be stimulated. But here is where another question pops up – is IPRS the main stimulant for innovation? In the next paragraphs we will try to give arguments over the basic hypotheses that IPRS have influence over the innovation process and the economic growth as a whole and in wine industry in particular.

3. Intellectual Property Rights: History and Importance

Whenever people think about IPRS itself, it is about all the positive sides and the mainstream idea of the system. It is true that to some extent it has a major impact on the work of an inventor (whether it is negative or positive) and it is of great importance to the whole activity. We can use the following example as it is an exact way to describe what an ordinary opinion of a person, who hasn't made a vast research on the topic about the process, is – if we accept the inventor and his motivation as an engine, then the patent is the fuel to the engine. Moreover, it's goal is to give meaning to the work of a genius and as Abraham Lincoln stated the US patent system “*added the fuel of interest to the fire of genius, in the discovery and production of new and useful things*”. (Lincoln 1858, cited in Andrews, 2017).

As we can see the idea and the basic opinion of people to patents is mostly positive. But is the patent itself so crucial to the period of modern economic growth (the beginning) and to the process of inventing, or is it just a small piece of the big puzzle? Is the effect large enough to account for a decent part of the increase and acceleration of technological progress?

This is a vast topic to which there are a lot of views. All the opinions have to be taken into account as they all have their strong arguments. Thus, we can make a better and correct conclusion. The main idea of the patents as discussed above is securing and motivating inventors, but just as many other positive policies, it can be used in an unfavourable way as well.

Many believe that we can support the statement that IPRS made at least some contribution to inventive activity and one of their arguments is that patenting became more common after 1760, exactly when England began to industrialize. Figure 1 shows the

period between 1660 and 1851 (the last full year before the system underwent reform):

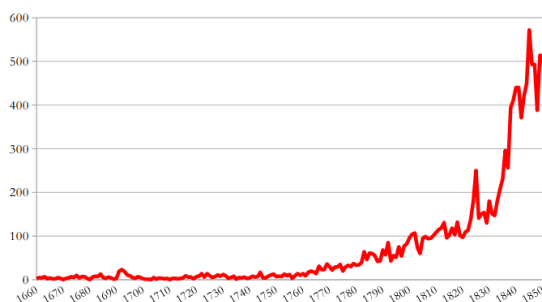


Fig. 1 English patents, 1660-1851

Source: Bottomley, S. (2013)

As we can see, the number of patents filed in Britain each year, seem to track the Industrial Revolution. But the problem here is that we cannot take this information as an evidence for the fact that patents have such a big influence – more information is needed to prove that patents had such a big role in stimulating the processes that lead to modern economic growth.

It is important to mention that Britain's patent system was not new and had many aspects in it that needed to be changed. For example, the US patent system was totally renewed when they declared independence. The British IPRS hadn't been renewed until 1852 when the big reform took place. This is why the graph is showing the number of patents until 1851 – we would like to observe the period of the First Industrial Revolution and the old patent system. Then, filing and taking out a patent was very expensive and time-consuming. For England alone the patent fee was 100£, but for the Kingdom as a whole it was 350£, without taking into account all the other costs (e.g. travelling, time, etc.). Based on the statement of Joel Mokyr (2009), he gives an example with candidate-patentee Samuel Taylor, who spent 125£ on filing a patent in 1772, and in addition had to be in London for 6 months away from his home and business. As a multiple of average earnings, the value of 125 in 1800 would equate to around 130 000£ today, and around 95 000£ in 1850. The inventor was responsible for the physical transmission of their petition through every step.

Moreover, the attitude of judges for example in this period was hostile as they considered patentees as monopolists. It is more than obvious that the whole process of filing a patent was not either easy or pleasant and because of this it has been described as "tortuous labyrinth" by Charles Dickens (1850).

However, a work suggests that the British patent system was adaptable, and that important changes really occurred to improve the whole process that a patentee had to go through (in terms of accessibility, enforceability) during the eighteenth and early nineteenth centuries (Cornish, 2010; Gubby, 2012; Bottomley, 2014). One of these improvements was the appearance of patent agents in the third quarter of the eighteenth century. This was a step of development as by employing an agent, it was no longer necessary for the inventor to transmit his petition through the different points, offices in person, and since then there was actually very little they had to do to reach the point of filing the patent. Most agents would have maintained contacts with manufacturers or investors for the benefit of their clients.

It was only around 1830, when an apparent change in the attitudes towards patentees occurred. Judicial hostility as mentioned above was replaced by a growing appreciation of the role of a patent in encouraging invention.

After the patent system was reformed in 1852, there was a sharp increase in the number of patents filed. We can derive to the fact that the whole process was problematic to the inventors.

4. Having the right of deciding the future of your invention?

Another argument that supporters of the IPRS have is that it gives the inventor the right of deciding the future of his invention. In theory, by allowing them to exclude other parties from using their invention, patents help inventors to make a return for their time and capital, invested for the inventing process, and thus incentivize the development of new technology. But did this really have such a significant impact on the development of Modern Economic Growth?

During the Industrial Revolution, inventors were able to enforce this exclusion on potential competitors. The problem here, however, is whether they could actually benefit from their inventions and use the patents to make their returns.

Even today the start of the manufacturing of an invention is a time and capital consuming process. As we saw above, agents made the links between the inventor, investor and manufacturer. But this means that the profits from their invention are not going to be fully for them. The reasons for this are:

1. Many inventors were not able to commercialize their inventions themselves this is why would either license or sell their patent. They could realize returns without going into business.
2. Some sold a portion of their patent as a part of a partnership agreement. This is how they would commercialize the invention without sufficient capital.

Of course, there were many inventors during the Industrial Revolution that failed to put their product on the market and ended their days in poverty – John Kay, James Hargreaves and Richard Trevithick. Cases like these have always questioned IPRS and its efficiency. Moreover, many of the important inventors of the Industrial Revolution viewed the patent system in a negative way and preferred not to use it. The ethics and understandings of these inventors were totally different. They stated that their motivation does not come from the materialistic side of the process. It comes from their dedication and passion to the invention activity as Claude Berthollet (Grand, 1976) wrote to James Watt – "When one loves science, one had little need for fortune which would only risk one's happiness". The same goes for the technological field as most of the engineers, Watt being an exception, were against the filing of patents.

Patents are not the only incentives for inventors, though. For example prizes in some cases could be decisive, especially in the famous case of the marine chronometer: the prize was given to all people who participated in the invention and improvement to the invention, and not only to the inventor John Harrison. The understanding of society was that if they wanted technological progress, the whole invention activity should be more financially attractive no matter whether there were patents or not. In some areas technological advancement was not so competitive, unlike the consequences of the patent system.

We could still argue further with the statement that only IPRS stimulated technological progress in the beginning of the period of Modern economic growth. It is a known fact that development in technology is a continuous process and for the faster and easier development, inventors need to build up on the technology that has been made until this very moment. But to do so they needed to have a license or to buy information of the patent holder. It was discussed above that when a patent was filed, the patentee would be given a period of 14 years (and in some cases the time could be prolonged, e.g. Watt's famous patent from 1769 to 1800) to put his invention on the market and make a return for his work. Therefore, it was highly difficult and expensive for other inventors to take the risk of investing in the knowledge without being sure that improvements could really be made. More information to the public was needed so that an improvement to products could be made and not thinking of new and similar products.

The process of building up on an invention in a free and united thinking market was termed by Robert C. Allen (1983) as “collective invention” – the main actors in technological innovation freely sharing information and claiming no ownership as the goal was development. Within the technical committees of the Society of Arts, for example, people shared ideas and “sharpened minds” with the others that were engaged in similar occupations and, thus, the process of innovation was faster. The example which Robert Allen gives in his paper is about the changes in the blast furnace practice that were developed in England’s Cleveland district between 1850 and 1875. Two major improvements were made, respectively in the height and temperature of the furnace by different parties, and in the end they were combined so that all could benefit from the innovative method.

However, there are many examples of how innovation has been suppressed because of this law. One of them is the above-mentioned – the patent of James Watt, which is said to have been used for suppressing competition and keeping monopoly on the production and market of steam engines. Watt would always count on patents and this way the improvement to his steam engine would be left to no one except for him. Even when the Hornblower engine was put into production in the 1790s, Watt and his partner Mathew Boulton used the full force of the legal system to stop it.

After the expiration of Watt’s patents there was an explosion in the production and efficiency of engines and this is **a key argument that patents in some cases suppressed invention activity**. It was then when steam power came as the driving force of Industrial Revolution. Crucial inventions such as the steam train, the steam boat and the steam jenny came into usage. One of the key innovations was the high-pressure steam engine. Most of them were available by 1804. But not before Watt’s patent expired as none of the inventors wanted to face the same fate as Jonathan Hornblower.

One last example we would like to give is with Ireland, which possessed a patent system that derived directly from the one in England, yet it saw very little inventive activity in the eighteenth and nineteenth centuries (Bottomley, 2013) and remained an extremely poor and agrarian society – tragically evidenced by the Great Famine of 1845-1849. So society and the quality of life do matter and not only IPRS.

5. Patents in Wine Industry

Many authors investigate the patents established in wine industry based on the specifics of the product focusing on the essentials that different varieties of grapes, strains of yeasts, and technologies produce different types of wine. The well-known variations result from the very complex interactions between the biochemical development of the fruit, reactions involved in fermentation, and human intervention in the overall process. The researchers state that the final product may contain tens of thousands of chemical compounds in amounts varying from a few percent to a few parts per billion.

Baiano et al. (2013) report a detailed description of patents dealing with vine, microorganisms, additive, methods and apparatus, sensors usable to monitor the process, serving of wine, packaging, storage, and preservation. The review presents a summary of the main European, United States and International patents available on wine production and preservation. They describe the purpose of patents in wine industry and different patents varieties, i.e. patents in vine like Chardonnay I10V1-S, etc.; in microorganisms - for instance the European Patent EP 0226328 A3, WO 175774 A1, etc.; additive - the patent WO 119572 A2, EP 1964913 A1, WO 172147 A1, etc. In this context, their conclusion states that to obtain and to keep the highest censored properties by the exploitation of the potential characteristics of grapes must be achieved by combining **innovative producing and aging technologies**. In fact, it is possible to modify the grape expression by applying different wine-making procedures.

Another lesson that can be learned from the patent explosion is the rise of patent warfare. The question is basic in discussions and researches in USA stated that after the law changed on business-method patents, financial companies had to start dealing with patent-enforcement entities and numerous and continual threat letters of patent infringement, continually obtaining advice from counsel in order to deflect a finding of willful patent infringement if the companies were ultimately sued. Furthermore, and most relevant to wine, many of the larger patent-enforcement entities are universities. Universities are seeking to make money from their novel research and have not been hesitant to sue for patent infringement. In the wine industry, one of the largest U.S. patent holders is the University of California, Davis, which holds patents in many aspects of wine production, including patents on unique types of grapes themselves. The University of California and UC Board of Regents are no strangers to patent infringement cases in federal court in other technologies.

When most people think of patents, they think of new machines, new medicines, or improved manufacturing processes. Based upon the report of Brian Kaider who is a principal of an intellectual property law firm (called Kaider Law), these inventions are protected by “utility patents.” Some people may also be familiar with “design patents,” which protect a novel ornamental design. But, there is a third class of patents with which most people are unfamiliar, “plant patents.” As the name suggests, plant patents protect new plant varieties, such as a new strain of wine grape vine. Plant patents are a useful tool to protect new varieties of grape vines.

Growers should be aware not only of the ability to protect their discoveries, but of the basic requirements to obtain patent protection and the actions that may potentially jeopardize their opportunities to seek protection. A knowledgeable patent attorney, engaged early in the process, can help to identify those new varieties that are eligible for a plant patent and to avoid waiving potential patent rights.

6. Conclusion

Technological progress was and is a key factor for the development of an economy, and inventions and innovations are a crucial part. As we saw throughout the paper, patents are not the only incentives for inventive activity. Even if they were, they can be used both in a way that stimulates technological progress or suppresses it as it is with the example of Watt.

The role of IPRS in the period of the beginning of Modern economic growth was, to some extent, to promote ownership. Based on the economic researches, we tend to see patents as one of the most important factor of the process but when it comes to an inventor and more specifically the inventors from the specified period mentioned above – they were not motivated primarily by the desire to maximize profits. Of course, that does not mean that money is not an important figure for them, but their goals and priorities were on a higher scale.

To sum up, no matter whether the influence of IPRS was positive or negative in some cases, the role of it was evident and it changed the way people thought when it came to inventions. This is a topic for discussion, and as always there were different opinions of inventors of the system. The most important part, however, was that patents did not have that big of an influence in this period but they are as important as any other incentives. And although most parts of the paper are not in favour of the statement that IPRS had a big influence on the period of Modern Economic Growth, we would like to end with the following quote of Mark Twain: *“A country without a patent office and good patent laws is just a crab, and can’t travel any way but sideways and backwards.”*

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Real-time urban air pollution monitoring using unmanned aerial vehicles

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Abstract: *Measuring pollutant gases for real-time air quality monitoring is a challenging task that claims a lot of time of observation and large numbers of sensors [1]. Unmanned Aerial Vehicles (UAVs) equipped with different micro-sensors have been introduced for air quality monitoring, as they can offer new approaches and research opportunities in air pollution and emission monitoring instead of ground-based monitoring systems [2]. UAVs with mobile monitoring devices are an effective, flexible and alternative mean to collect air pollutant concentration data [3]. Hence, deployment of a fleet of UAVs could be considered as an acceptable alternative for the purpose of air monitoring [4]. The aim of this paper is to elaborate performance capabilities of UAVs for effective monitoring of air pollution, providing the ability to measure air pollutants with high sensitivities.*

KEYWORDS: UNMANNED AERIAL VEHICLES, AIR POLLUTION, MONITORING

1. Introduction

Air pollution has been identified as a leading risk factor for the global disease burden [5]. In response, air monitoring networks have been established to monitor concentrations of air pollutants in the ambient air.

Air pollution monitoring has recently become an issue of utmost importance in the society. Environmental organizations and governmental institutions are beginning to consider the monitoring of environmental pollutants as a primary goal [4].

Measuring air quality is important to make sure that the general public, governmental agencies and any involved party is conscious of the state of pollution, and to trigger taking the required precautions to ensure the safety of the population [1].

However, the current monitoring networks are often considered insufficient to cover large areas or implement effective pollution control strategies [5].

As the Unmanned Aerial Vehicles (UAVs) technology has gained popularity over the years, it has been introduced for air quality monitoring [3].

Spatial and temporal resolution of data from ground, manned aircraft and satellite measurements is relatively low and often inadequate for local and regional applications [2]. In addition, satellite and airborne sensors can be costly, restricting the use of these platforms to sporadic tests rather than routine analysis. Furthermore, taking measurements close to pollutant sources may not always be possible and it could be too dangerous or risky for manned aircraft to fly close to the ground [2].

All these reasons encourage the use of small, lightweight UAVs for a wide range of applications, including atmospheric measurements [6].

UAVs have the potential to be used for an enormous range of applications, many of which involve urban settings. A wide range of sensors, improvements in data post-processing, and continuing evolution of the drones themselves are expanding the potential uses [7].

UAVs can help to environmental researchers in the field of air quality monitoring. Hence, this paper elaborates the potential of UAVs for air quality monitoring, together with their advantages/disadvantages characteristics. Also, classification of UAVs is presented, which is important for analysis of their performance capabilities.

2. Introduction to Unmanned Aerial Vehicles (UAVs)

Assessment of air quality has been traditionally conducted by ground based monitoring, and more recently by manned aircrafts and satellites. However, performing fast, comprehensive data collection near pollution sources is not always feasible due to the complexity of sites, moving sources or physical barriers [2].

Additionally, satellite and sensors can be costly resulting to restrictions in the analysis. These limitations together suggest the

use of small, lightweight UAVs for atmospheric measurements and monitoring [3].

Recently, Unmanned Aerial Vehicles (UAVs) have become a cheap alternative to sense pollution values in a certain area due to their flexibility and ability to carry small sensing units [8].

Unmanned Aerial Vehicles (UAVs) are an aircraft without a pilot. Furthermore, these vehicles are remotely controlled, semiautonomous, autonomous, or have a combination of these capabilities. In a technological context, a drone is an unmanned aircraft, like a flying robot. The aircrafts may be remotely controlled or can fly autonomously through software controlled flight plans in their embedded systems working in conjunction with onboard sensors and GPS [6].

A UAVs system typically consists of the UAV itself, a ground station, and a few onboard gadgets, such as a first-person view camera [5]. In many applications, UAVs are simply used as a carrying platform and do not intervene with the operations of the onboard gadgets. The controls of the UAVs and the gadgets are often separated as well. For air quality monitoring, however, the UAVs must function beyond a simple platform that carries multiple air pollutant sensors. It is more important for the UAVs to integrate the data from all onboard sensors and tag the data with geo-location information in real time [5].

These small, lightweight UAVs can provide more accurate information on air pollutant vertical distribution throughout the atmosphere, which is needed to understand air quality and composition in specific atmospheric layers [3]. They are being used in various air quality control methods for measuring particulate matter and VOCs as well as measurements relating to meteorology such as temperature, humidity, pressure and winds.

In addition, UAVs are quickly deployable, cover large areas and can monitor remote, dangerous or inaccessible locations, increasing operational flexibility and resolution over land-based methods [6].

Therefore, UAVs may be a viable option for air quality data collection [2].

3. Classification of UAVs

As the use of drones for civil purposes is relatively new, there is no much of legislation existing yet [6]. However, in order to define legislation, a classification is needed previously to determine the different needs and requests.

There are two types of UAVs in existence that can help in determining air quality: fixed wing and rotary wing [1]. Fixed wing UAVs are comparative in configuration to planes used in human and cargo transportation. On the other hand, rotary wing UAVs are much similar to manned helicopters and are excellent for tasks that require the UAVs to stay still in one place or to move in a limited area [1].

Fixed wing UAVs can carry larger payloads, but must remain in an X-Y plane with constant motion. Rotary wing UAVs can only carry small payloads, but has the capability of collecting samples while it is in motion and also when it is hovering over a specific location [3]. UAV can be used successfully for this type of work

because they are light in weight and can fly from one place to another relatively easily.

Table 1 below gives an overview about the differences between fixed wing and rotary wing UAVs in terms of their advantages and disadvantages.

Table 1: Comparison between fixed wing and rotary wing UAVs

	Fixed Wing	Rotary Wing
Advantages	- High speed - Long distance traveling - Heavy payload - Smooth gliding through air (sleek structure) - Minimal maintenance process	- Multi directional (can hover) - No need for runway to takeoff or land
Disadvantages	- One directional (cannot hover) - Runway or launcher is needed to takeoff and landing - Commercial use is restricted by rules and regulations	- Complex design - Low operational time - High cost - Very light payload

Source: [1]

UAVs encompass a wide range of different platforms which, due to their physical size and power, differ in terms of their capability and simplicity of operation. These factors impact the payload carrying capacity, speed, altitude and range of flight, which determines the different applications that can be performed by each type of UAVs [2]. Figure 1 shows examples of fixed and rotary wing UAVs. The nomenclature adopted for civil and scientific use has generally followed the existing military descriptions of size, flight endurance and capabilities.



Figure 1: Example of a small fixed wing (a) CyberEye II; (b) Silvertone Flamingo; (c) SenseFly Swinlet and rotary wing (d) AscTec Pelican; (e) DJI F550; (f) DJI S800 unmanned aircraft (All the UAVs shown are part of the fleet of the Australian Research Centre for Aerospace Automation).

Source: [2]

Table 2 presents another classification of UAVs taking weight as criteria.

Table 2: Different types of UAVs on the basis of weight

Type of drone	Current and potential future uses	Current regulation
Small (<20/25kg) Price 140-28000€	Leisure and commercial use (e.g. surveillance, inspection, photography)	Falls under Member State regulations
Light (20/25-150kg) Price 55000-420000€	Used in geospatial surveying and wide-area surveillance. Potential to inspect pipelines and power cables, spray crops, search and rescue, control borders and monitor forest fires	Falls under Member State regulations
Large (>150kg) Price 670000€ and above	Used by the military and defense forces. Potential to carry cargo and passengers	Civil drones with an operating mass of more than 150 kg fall under Regulation 216/2008/EC and EASA competency, unless operated by a state agency

Source: [6]

UAVs can offer high resolution spatio-temporal sampling, which is not possible or feasible with manned aircraft [2]. Some UAVs systems are more flexible than others, with the ability to carry multiple sensors and operate in different flight modes (hybrid rotary/fixed wing designs).

Questions still need to be addressed regarding the miniaturization of sensors, which seems to be the main issue when working with lightweight UAVs [2]. In fact, the diverse range of UAVs payload capacity is primarily made by the difference between rotary and fixed wing UAVs.

4. Performance and capabilities of UAVs

UAVs are operationally more versatile and visible compared to land-based approaches or other aerial methods, such as manned aircraft and satellites. Conducting atmospheric measurements in remote locations is one situation where the use of small, lightweight UAVs is of particular benefit. In fact, the reduced size, weight and power needs of these flying robots, along with the reduced cost of the platforms and instrumentation, make them highly suitable for these operations [2].

UAVs or drones can carry a wide range of sensors with an equally wide range of applications to aerial points that were previously expensive, or impossible, to reach [7]. Depending on the sensors used, multiple data sets may be collected with a high spatial and temporal resolution [2].

Potential applications include [7]:

- Sampling air quality over a broad area in a short period of time, using a fixed-wing drone: this application would dramatically improve air quality information but at a significant risk to safety.
- Sampling pollution point sources, such as an industrial or a construction site: research is required to determine the reliability of air samples taken by drone from above a site, compared to those taken at or near-ground; this may lead to greater compliance of industry to environmental regulations.
- Sampling vertically, using a rotary wing drone at a single GPS location: this may help to predict near-future changes in ground-level pollution, particularly of particulate matter.
- Research: improve our understanding of the movement of pollutants during specific meteorological and temporal conditions.

5. Pros and cons to UAVs and current challenges

For every new technology to be accepted as a research tool, showing the advantages is most important. In addition, disadvantages could become a driving force for the future research. This also applies to the technology of UAVs.

Table 3 presents advantages and disadvantages if the process of usage of UAVs as a small robotic platforms for air quality research.

The advantages of a UAVs must outweigh the disadvantages and also be competitive with ground-based methods. If UAVs are adopted on a wide scale and if their advantages are studied and proved, than the balance between advantages and disadvantages could be found.

This emerging unmanned aircraft technology faces challenges that somehow slow down the development. The increase in drone use which recently gains popularity raises privacy concerns and even the word “drone” has a real negative first impression [3].

Table 3: Overall advantages and disadvantages for the use of UAVs in the atmospheric research domain

Advantages	Disadvantages
flexibility: available wide range of UAVs applications	payload, speed, power and endurance limitations at small, low-cost UAVs
safety: no risk for crew in dangerous environments (chemical, biological or radiological hazards)	safety: risk of aerial collisions with piloted aircrafts, wildlife, and inanimate objects and collisions to ground level [7]
time and cost savings: especially with small UAVs platforms	security, including privacy [7]
repeatability: the same programmed flight could be followed every time by ground station	flight issues: interference with other instruments (vibration effect) [3]
data collection: small UAVs can take measurements at any point in three dimensional space	sensors limitations: availability of professional sensors and sensor integration into a network
easy to deploy – no need for airport runways	sensor size limitations: smaller sensors may have less sensitivity
national regulation in many countries for the use of UAVs [3]	aerospace regulation: operating regulations of UAVs aren't globally defined

Source: according to [2]

Table 4: Challenges in UAVs-based air monitoring platform

Low-cost UAVs. Proprietary professional UAV platforms are expensive and require specialized design and maintenance; also do not allow the general users to customize their needs.
Synchronization of monitoring sensor data and GPS data. For real-time monitoring and geospatial data modeling, air pollutant data and GPS data need to be synchronized, as they come from two separate components.
Multiple air pollutants. Both the scientific community and regulatory agencies have been shifting from the traditional single-pollutant approach toward a multi-pollutant approach to quantify the health consequences of air pollution mixtures. This trend requires a platform that can integrate multiple sensors with different operating principles.
Energy efficiency and flight time. A typical UAVs in the price range of \$500 to \$2000 can fly for about 15 to 30 min on one fully charged battery. Carrying additional devices may reduce the UAVs flight time, as the onboard devices add weights to the UAVs and the devices themselves consume electricity. A typical USB-powered micro-controller device consumes power in the range of 1 W to 10 W. It is necessary to study and find a design with hardware and software to reduce the weight and energy consumption of the UAVs system.
Safety and restrictions in cities. UAV's flight paths need safe airspace to avoid many obstacles in a city environment, such as buildings, lights, power distribution lines, trees, no-fly zones and so on. Also, UAVs cannot be deployed without restrictions. Under current aviation safety operating regulations, restrictions are placed on their use in commercial, research, and private applications.

Source: [5]

However, the challenges are not simply technological, in fact, policy and regulations, which differ between countries, represent the greatest challenge to facilitating the wider use of UAVs in atmospheric research [2].

However, with more complexity and capability comes more maintenance, and additional specialist skills may be required. Larger platforms are costly and require a significant financial investment. Perhaps, the most important consideration is the safety of using such platforms in commercial applications, since they have the potential to cause considerable damage (to humans and property) and as such, fall under stricter operating guidelines than smaller UAVs [2].

6. Conclusion

To quantify the effects of atmospheric pollution on human health and environment, detailed information on the characteristics of pollutant concentration is needed. However, data from ground bases and satellite measurements are relatively low and often inadequate [3].

In recent years, to deal with the aggravation air pollution, the Unmanned Aerial Vehicles (UAVs) have been widely used to monitor the pollutant air. The UAVs monitoring system is expected to be an effective emergency tool for monitoring air pollutant thanks to its high resolution, flexibility, quick response, subjectivity, accuracy and impregnability of the terrain [9].

The Unmanned Aerial Vehicles are becoming an attractive experimental platform for high-spatial-resolution, near-surface vertical profiling of atmospheric pollution in recent years [5]. Recent advancements in UAVs technology present a low-cost solution for sampling the lower troposphere, taking advantage of their abilities to maneuver in both the horizontal and vertical dimensions and to hold a fixed position in the air even under high-wind conditions [5].

Hence, this paper outlines the main capabilities of UAVs, together with their classification and performance applications.

The future of UAVs for use in air quality applications is promising, thanks to the capability and flexibility of robotic platforms [2].

Promising characteristics of UAVs are long flight duration, improved mission safety, flight repeatability due to improving autopilots, and reduced operational costs when compared to manned aircrafts [3].

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Evenness and unevenness in cylindrical milling

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Abstract: High-speed milling is one of the new modern technologies in machining. It is radically different from the known method of the conventional milling in fundamentally different process specified by the modified mechanism of the cutting process. This article presents a theoretical model to determine the coefficient of unevenness aimed at giving information whether already selected cutting conditions in cylindrical milling is admissible. This makes it possible to use the power of the machine most conveniently, to improve the quality of the machining and to achieve a relaxed operation. The model is based on derived mathematical equations.

KEYWORDS: CYLINDRICAL MILLING, UNEVENNESS OF MILLING, MILLING CUTTER

1. Introduction

Analyzing modern milling operations, especially high speed routing [1, 2] (Fig. 1), the following conclusions can be drawn:

- The trajectory of the relative working motion in the machining process varies depending on who performs the rectilinear and rotational movements – the tool or workpiece;
- The tool movement trajectory is changed in order to achieve the uniform thickness of the cut metal layer, increasing the tool's durability and achieving a high quality of the machined surfaces.

In order to analyze this scenario, it is necessary to introduce a concept of a "momentary trajectory" and to define the main possible variants, the combination of which requires an analysis of the momentary working angles of the tools.

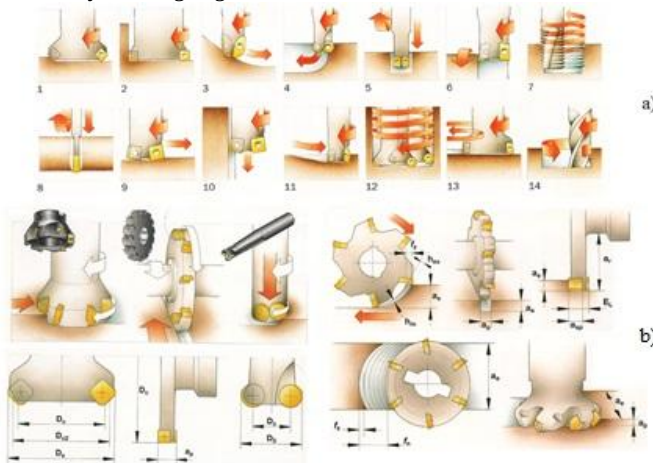


Fig. 1. Milling schemes [3, 4]

a) Kinematic schemes of milling; b) Basic technological parameters

2. Development of the theoretical model

It is considered that there is evenness of milling, when the total cross-section of the chip and the total tangential cutting force retain its size constant [5, 6]. With straight teeth cutters, it is impossible to obtain evenness, because when the tooth comes out of the material treated (counter-milling), the total cross-section of the chip and the total tangential cutting force change its value suddenly [7].

The fact, when milling with helical mill the tooth leaves the material treated, allows the selection of the working conditions so that the total cross-section of the chip and the total tangential cutting force to remain unchanged [8]. When using helical mills such cutting conditions are achieved when the milling width B is multiple of the axial pitch of the milling cutter – t_{oc} .

$$\frac{B}{t_{oc}} = C \quad (1)$$

where: C is degree of evenness of the milling (a whole or a fractional number can be obtained).

Fig. 2 shows a method for graphically determining the unevenness of milling, and the helical mill is shown unfolded. By comparing the sections of the individual chips from teeth I and IV, it is seen that they complement each other to obtain a complete triangle. With movement the material in the direction of arrow 2, it moves to the left (to the tooth I) and the triangles belonging to the teeth. In this case the area of the cross-section of the chip I will be reduced as much as that of the tooth IV increases. The same picture is also observed between teeth II and V, III and VI (not shown in fig. 2).

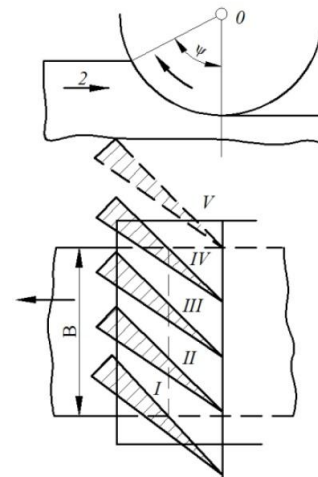


Fig. 2. Graphically determination of milling unevenness

Therefore, at a multiplicity between the milling width and the axial pitch, the milling cutter at any time works with the same total cross-section of the chip, leading to equal forces, torque and power. To determine under what working conditions can have evenness will be rework the Eq.(1) as follows:

$$\frac{B}{t_{oc}} = \frac{B}{\frac{\pi \cdot D}{z \cdot \tan \omega}} = C \rightarrow \frac{B \cdot z \cdot \tan \omega}{\pi \cdot D} = C \quad (2)$$

where: z – number of teeth; $\tan \omega$ – helical angle; D – diameter of the milling cutter, mm.

With the help of Eq.(2), it is possible to select such values of diameter, number of teeth and helical angle of the milling cutter to ensure the required evenness at the given milling width.

It is advisable that the choice of the constant to be within the range $C=2\div 3$.

With the increase of the C increases the number of simultaneously working teeth, which increases the power consumption and forces acting on the mandrel and the machine table.

The number of simultaneously working helical teeth at milling is defined as follows:

$$k_h = k_{str} + C \quad (3)$$

where: k_{str} – number of teeth milling cutter with straight teeth.

With the help of the last equation, the number of teeth and helical angle can be determined at a given cutter diameter and accepted value of C :

$$k_{str} = k_h - C = \frac{z}{\pi} \cdot \sqrt{\frac{t}{D}} \quad (4)$$

from here

$$z = \pi \cdot (k_h - C) \cdot \sqrt{\frac{D}{t}} \quad (5)$$

The helical angle is obtained from the Eq.(2)

$$\tan \omega = \frac{C \cdot \pi \cdot D}{B \cdot z} \quad (6)$$

This method of calculation is approximate. More accurate results are obtained using the unevenness coefficient.

High milling performance is achieved when working with large feeds, i.e. when each tooth removes from the workpiece a high-thickness chip. When determining the cutting conditions, typically t and B are set. If the tool with a certain number of teeth z and diameter is also given, by changing the number of rotational frequency n and the feed s_z , it is possible to achieve full use of machine power.

Greater productivity at higher feeds s_z also leads to higher cutting forces and hence increased load on the milling mandrel and kinematic components of the machine. However, each machine has a certain load limit that can withstand without disturbing its normal operating mode. Therefore it is essential to know the actual forces occurring at the cutting. So far, average power and torque have been determined. However, calculating cutting mode and machine parts with average loads is unacceptable as periodic overloading of the machine components would be allowed. Maximum force and torque values are significantly higher than their average values. Moreover the degree of overrun is different and depends on the working conditions.

Therefore, it is important to define the cutting conditions with a minimum fluctuation in the magnitude of the forces and torques. This makes it possible to use the power of the machine most conveniently, to improve the quality of the machining and to achieve a relaxed operation.

However, in order to assess whether an already selected cutting mode is acceptable, the coefficient of unevenness should be determined:

$$\mu = \frac{(\sum P)_{max}}{P_{aver}} = \frac{M_{max}}{M_{aver}} \quad (7)$$

where: μ is coefficient of unevenness obtained from the ratio between the sum of the maximum and the average tangential force at milling or the ratio between the maximum and the average

torque. The coefficient μ indicates how many times the maximum tangential force and torque exceed the average values.

To find the coefficient at milling with a straight teeth milling cutter, it is necessary to determine successively the P_{aver} and $(\sum P)_{max}$. So the expression for P_{aver} will be:

$$P_{aver} = \frac{2^{m+1}}{m+2} \cdot C_p \cdot \frac{t \cdot z}{\pi} \cdot s_z^{m+1} \cdot \sin^{m+2} \frac{\psi}{2} \quad (8)$$

where: m – exponent which depends on the quality of treated material, having a fractional and negative value; C_p – coefficients, depending on the quality of the treated material and the cutting angle; p – specific resistance to cutting, N/mm^2 .

Here the angle ψ is the contact angle defined by the ratio t/D . For $(\sum P)_{max}$ can be written:

$$(\sum P)_{max} = \sum B_{a\delta} \cdot p, p = C_p \cdot a_{\delta}^m; a_{\delta} = s_z \cdot \sin \delta \quad (9)$$

where: δ is the angle determined by the current position of the tooth; a_{δ} – the thickness of the chip for 1 tooth at a time when the tooth is at an angle δ , mm . Finally for $(\sum P)_{max}$ can be written:

$$(\sum P)_{max} = C_p \cdot B \cdot s_z^{m+1} \cdot (\sum \sin^{m+1} \delta)_{max} \quad (10)$$

By substituting Eq.(8) and Eq.(9) into Eq.(10), it is possible to determine the coefficient of unevenness:

$$\mu = \frac{(\sum P)_{max}}{P_{aver}} = \frac{m+2}{2^{m+1}} \cdot \frac{\pi \cdot (\sum \sin^{m+1} \delta)_{max}}{z \cdot \sin^{m+2}(\frac{\psi}{2})} \quad (11)$$

If the center angle between two adjacent teeth of the milling cutter is indicated by φ , it will be obtained:

$$(\sum \sin^{m+1} \delta)_{max} = \sin^{m+1} \psi + \sin^{m+1}(\psi - \varphi) + \sin^{m+1}(\psi - 2\varphi) + \sin^{m+1}[\psi - (k-1)\varphi] \quad (12)$$

where: k is the number of simultaneously working teeth; ψ – contact angle, $^\circ$.

Substituting $\frac{\varphi}{\psi} = u$ in Eq.(12) and is eliminated φ in the expression. Then substituting Eq.(12) into Eq.(11) and by using equality $\frac{\varphi}{\psi} = u$ for μ is obtained the expression:

$$\mu = \frac{m+2}{2^{m+2}} \cdot u \cdot \psi \left\{ \frac{\sin^{m+1} \psi + \sin^{m+1}[\psi \cdot (1-u)]}{\sin^{m+2} \frac{\psi}{2}} + \frac{\sin^{m+1}[\psi \cdot (1-2u)]}{\sin^{m+2} \frac{\psi}{2}} + \dots \frac{\sin^{m+1}[\psi \cdot (1-(k-1)u)]}{\sin^{m+2} \frac{\psi}{2}} \right\} \quad (13)$$

The Eq.(13) shows that the coefficient of unevenness depends on the ratio $u = \frac{\varphi}{\psi}$ and m . The influence of the contact angle $\psi=8^\circ \div 60^\circ$, which corresponds to the ratio $t/D = 0,005 \div 0,25$, on μ is insignificant, therefore the calculations are not taken into account and work with μ_{avg} , which is reported by a table 1. To simplify the calculations of μ , we work with an average value of $m = -0.3$, which leads to some errors. However, they are acceptable and do not exceed the unevenness of the unavoidable ordinary runout of the milling cutter.

The greatest influence on μ has the ratio u (see table 1).

Table 1 Influence of ratio u on the coefficient of unevenness μ

$u = \frac{\varphi}{\psi}$	μ		μ_{avg}
	$\psi=8^\circ$	$\psi=60^\circ$	
0,2	1,155	1,155	1,155
0,4	1,36	1,36	1,36
0,6	1,54	1,52	1,53
1,0	1,68	1,60	1,64
1,5	2,52	2,40	2,46
2,0	3,36	3,20	3,28
3,0	5,04	4,80	4,92
5,0	8,40	8,00	8,20

When milling with helical mills, the average tangential force P_{ω} is calculated as for cutters with straight teeth.

$$(\sum P_{\omega})_{max} = D \cdot C_{\omega} \cdot C_p \cdot ctg \omega \cdot s_z^{m+1} \cdot \frac{2^{m+1}}{m+2} \left[\sin^{m+2} \left(\frac{\delta_2}{2} \right) - \sin^{m+2} \left(\frac{\delta_1}{2} \right) \right]_{max} \quad (14)$$

For Paver can be written:

$$P_{aver} = \frac{2^{m+1}}{m+2} \cdot C_{\omega} \cdot C_p \cdot \frac{B \cdot z}{\pi} \cdot s_z^{m+1} \cdot \sin^{m+2} \frac{\psi}{2} \quad (15)$$

where: ω is helical angle of the tooth; δ_1 and δ_2 are angles determined by the current position of the edges of each tooth of the milling cutter.

The coefficient of unevenness will be:

$$\mu = \frac{(\sum P)_{max}}{P_{aver}} = \frac{\pi \cdot D \cdot ctg \omega \cdot \sum \left[\sin^{m+2} \left(\frac{\delta_2}{2} \right) - \sin^{m+2} \left(\frac{\delta_1}{2} \right) \right]}{B \cdot z \cdot \sin^{m+2} \frac{\psi}{2}} \quad (16)$$

$$\mu = \frac{t_{oc}}{B} \cdot \frac{\sum \left[\sin^{m+2} \left(\frac{\delta_2}{2} \right) - \sin^{m+2} \left(\frac{\delta_1}{2} \right) \right]_{max}}{\sin^{m+2} \frac{\psi}{2}} \quad (17)$$

where: t_{oc} is axial pitch between two adjacent teeth (see fig.3).

Through certain substitution the Eq.(17) can be reworked, but

for easier finding it is solved graphically depending on $\frac{\varphi}{\psi}$ and

$$\frac{B}{t_{oc}}$$

Figure 3 shows graphically the change of the coefficient of unevenness μ . The chart shows that the decreasing of $\frac{\varphi}{\psi}$ is decreases and the coefficient μ . For its part, $\frac{\varphi}{\psi}$ can be decreased or by increasing the number of teeth of the milling cutter at constant t of the ratio t/D , or by increasing t/D at constant z .

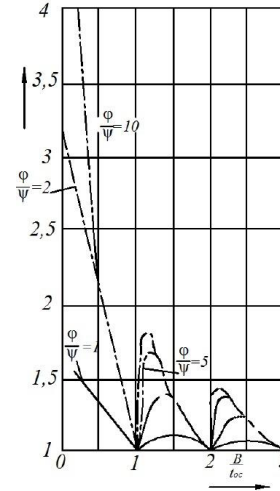


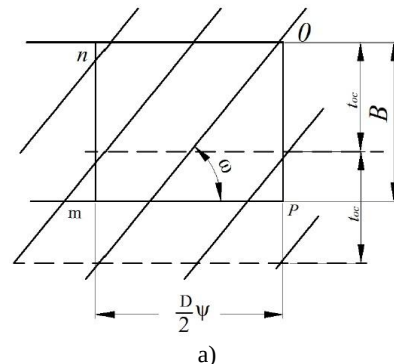
Fig. 3. Graphically representation of the changing of the coefficient of unevenness μ

3. Conclusions

1. Upon change of $\frac{B}{t_{oc}}$ the coefficient μ is changed periodically, as for values of $\frac{B}{t_{oc}}$ equal to integers, μ decreases to one (achieving evenness of milling). For the intermediate values of $\frac{B}{t_{oc}}$, μ in the beginning grows, reaches a certain maximum and then decreased to 1. From the above it follows that the maximum of the coefficient of unevenness μ does not coincide with the maximum of the degree of unevenness C .

Knowing the $\frac{B}{t_{oc}}$ and $\frac{\varphi}{\psi}$ from the graph can be easily defined μ . If they are multiplied by μ the average values of P and M_p (permissible torque), the maximum sizes of P and M_p will be obtained for a certain cutting mode.

From figure 4 it can be seen that at $\frac{B}{t_{oc}} < 1$ and $\frac{\varphi}{\psi} > 1$ the coefficient of unevenness reaches large values.



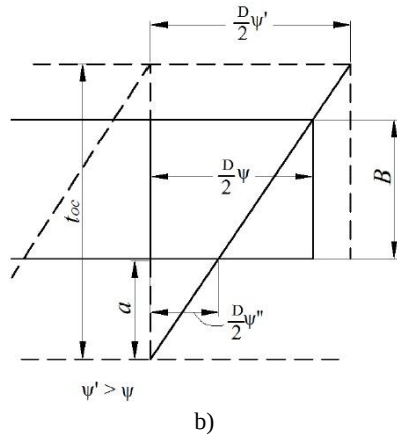


Fig.4 Sequential position of the helical teeth of the milling cutter
a) at $B > t_{oc}$; b) at $B < t_{oc}$

2. In milling, such ratios are not excluded in the practice. Designed for heavy-duty modern cutters are made with a limited number of teeth, as a result of which, given the above conditions, a large coefficient of unevenness can easily be obtained. From the graph, it can be seen that at milling good evenness can be achieved

by decreasing $\frac{\varphi}{\psi}$ and increasing $\frac{B}{t_{oc}}$. To reduce the $\frac{\varphi}{\psi}$ is needed

for a given depth of cutting or to reduce the diameter of the milling cutter, or to increase the number of teeth. The above is inappropriate that is why a limited number of teeth ($z = 6$ to 12) are being chosen when creating a high-performance milling cutter.

3. Reducing of the diameter of the milling cutter is limited by the strength of the milling mandrel. It is most expedient to reduce the coefficient of unevenness by increasing the ratio $\frac{B}{t_{oc}}$.

Milling cutters with great ratio $\frac{B}{t_{oc}}$ have a large helical angle and a

small axial pitch t_{oc} between the teeth. Modern high-performance milling cutters have a large helical angle and a limited number of teeth.

4. With sufficient accuracy, the same graph can also be used to determine the coefficient of unevenness for the horizontal force P_h with the expression $P_{hmax} = \mu \cdot P_{haver}$.

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Energy (isentropic) analysis of three-cylinder steam turbine with re-heating

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Abstract: In this paper is presented energy (isentropic) analysis of high power, three-cylinder steam turbine with steam re-heating. A comparison of real (polytropic) and ideal (isentropic) steam expansion processes at nominal load show that observed turbine develops real power of 655.35 MW, while in ideal situation it can develop 716.18 MW. The highest energy loss and the lowest energy efficiency occur in the high pressure turbine cylinder (25.67 MW and 89.14%), while intermediate pressure cylinder has the highest energy efficiency and the lowest energy loss. The energy efficiency of the whole observed turbine is 91.51%, what is in the expected range for such high power steam turbines at nominal load. Further optimization of this steam turbine will be primarily based on the high pressure cylinder.

KEYWORDS: ENERGY (ISENTROPIC) ANALYSIS, STEAM TURBINE, ENERGY EFFICIENCY, ENERGY LOSS

1. Introduction

Steam turbines are the dominant power producers which drive electric generators for the electricity production worldwide [1]. Steam turbines can operate in conventional power plants [2], combined power plants (where steam is produced from flue gases of gas turbine) [3], marine power plants [4] and many others.

Steam turbines are complex power producers which consist of many stages, elements and sub-systems. In various power plants can be found steam turbines which consist of several cylinders (single-flow or dual-flow) as well as steam re-heater due to many benefits which it brings in entire power plant operation [5]. However, many low power steam turbines usually consist of only one single-flow cylinder (in some situations it can also be only one Curtis stage) for the drive of auxiliary components (pumps, compressors, etc.) [6].

In this paper is performed energy (isentropic) analysis of high power steam turbine, which consists of three cylinders and has a re-heater between high pressure and intermediate pressure cylinders. The analysis is performed for each turbine cylinder as well as for the whole steam turbine. Calculated power distribution, energy efficiencies and losses for the whole turbine and each of its cylinders at nominal load present interesting overview of turbine operation, while the obtained conclusions can be used as a guideline in future research and improvements.

2. Description and operating process of the analyzed three-cylinder steam turbine with re-heating

Analyzed steam turbine consists of three cylinders: High Pressure Cylinder (HPC), Intermediate Pressure Cylinder (IPC) and Low Pressure Cylinder (LPC). All the cylinders are connected to the same shaft which drives an electric generator, as presented in Fig. 1.

Steam produced in steam generator [7] is delivered to HPC which has two steam extractions - both of them lead steam to high pressure feed water heaters [8]. After expansion in HPC, remaining steam mass flow rate is lead to steam re-heater, which increases steam temperature (along with pressure drop due to losses which occurs in re-heater). After re-heater steam enters into IPC which also has two steam extractions - first extraction leads steam to high pressure heater while second extraction leads steam to the deaerator. Remaining steam mass flow rate which exits IPC enters in LPC. LPC has three steam extractions - all of them lead steam to low pressure feed water heaters [9]. After expansion in LPC, remaining steam mass flow rate is lead to steam condenser for condensation [10].

It should be noted that steam mass flow rates leaked through the front and rear gland seals of each cylinder [11] are neglected in this analysis due to lack of such data. However, in real operation, steam mass flow rate leaked through both gland seals of each turbine cylinder will be led to gland steam condenser [12].

Fig. 1 also presents operating points required for the observed turbine and all of its cylinders energy (isentropic) analysis.

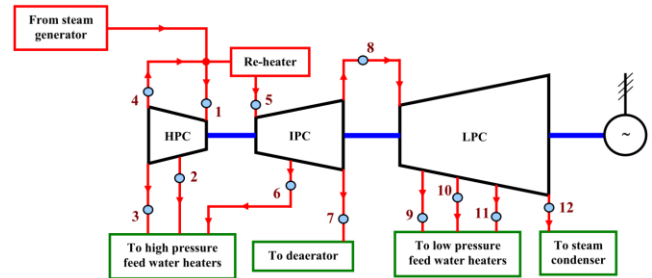


Fig. 1. General scheme of steam turbine along with operating points required for the analysis

Steam expansion processes of each analyzed turbine cylinder (real and ideal) in h - s diagram are presented in Fig. 2. Real (polytropic) expansion processes are: for the HPC - 1-2-3; for the IPC - 5-6-7 and for the LPC - 8-9-10-11-12, while ideal (isentropic) expansion processes are: for the HPC - 1-2is-3is; for the IPC - 5-6is-7is and for the LPC - 8-9is-10is-11is-12is. According to those operating points for both expansion processes in each turbine cylinder, presented in Fig. 2, will be shown operating parameters obtained during the turbine exploitation (real process at nominal turbine load), as well as operating parameters of ideal expansion (obtained by retaining constant steam specific entropy in each turbine cylinder).

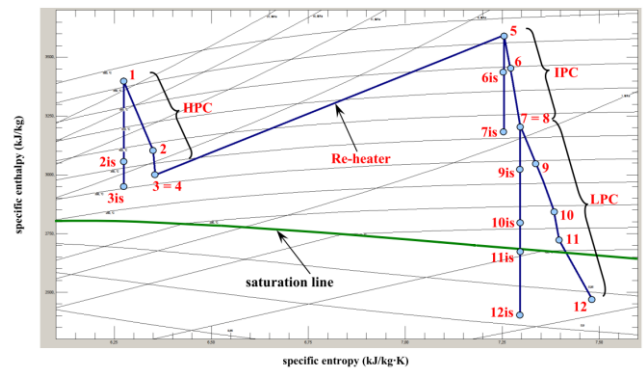


Fig. 2. h - s diagram of the real (polytropic) and ideal (isentropic) expansion processes inside each cylinder of the analyzed steam turbine

3. Energy analysis equations

3.1. Overall energy analysis equations

Energy analysis is defined by the first law of thermodynamics [13] and is independent of the ambient conditions in which control volume or a system operates. Mass and energy balance equations for a control volume or a system in steady state, disregarding potential and kinetic energy, can be expressed according to [14] as:

$$\sum \dot{m}_{IN} = \sum \dot{m}_{OUT} , \quad (1)$$

$$\dot{Q}_{IN} + P_{IN} + \sum(\dot{m}_{IN} \cdot h_{IN}) = \dot{Q}_{OUT} + P_{OUT} + \sum(\dot{m}_{OUT} \cdot h_{OUT}) \quad (2)$$

where $\dot{m}$ is mass flow rate (kg/s), $\dot{Q}$ is heat transfer (kW), P is power (kW), h is operating medium specific enthalpy (kJ/kg), IN denotes input (inlet) and OUT denotes output (outlet).

Operating medium energy flow [15] is calculated as:

$$\dot{E} = \dot{m} \cdot h, \quad (3)$$

where $\dot{E}$ is energy flow of operating medium (kW).

General definition of control volume or system energy efficiency is [16]:

$$\eta = \frac{\text{energy output}}{\text{energy input}}, \quad (4)$$

where η is energy efficiency (%).

Mentioned overall equations are used in the energy (isentropic) analysis of observed steam turbine and each of its cylinders.

3.2. Energy (isentropic) analysis of the observed steam turbine

Energy (isentropic) analysis of entire observed steam turbine and each of its cylinders is based on the comparison of real (polytropic) and ideal (isentropic) steam expansion processes.

Equations for the calculation of all required variables in energy (isentropic) analysis of the observed turbine and its cylinders are presented in Table 1 and Table 2. In Table 1 are presented equations for HPC and IPC, while in Table 2 are presented equations for LPC and whole turbine. Markings in all the equations from Table 1 and Table 2 are defined in accordance to Fig. 2.

Table 1. Equations for the energy (isentropic) analysis of steam turbine HPC and IPC

	HPC	Eq.	IPC	Eq.
Real (polytropic) power (kW)	$P_{HPC, re} = \dot{m}_1 \cdot (h_1 - h_2) + (\dot{m}_1 - \dot{m}_2) \cdot (h_2 - h_3)$	(5)	$P_{IPC, re} = \dot{m}_5 \cdot (h_5 - h_6) + (\dot{m}_5 - \dot{m}_6) \cdot (h_6 - h_7)$	(10)
Ideal (isentropic) power (kW)	$P_{HPC, is} = \dot{m}_1 \cdot (h_1 - h_{2is}) + (\dot{m}_1 - \dot{m}_2) \cdot (h_{2is} - h_{3is})$	(6)	$P_{IPC, is} = \dot{m}_5 \cdot (h_5 - h_{6is}) + (\dot{m}_5 - \dot{m}_6) \cdot (h_{6is} - h_{7is})$	(11)
Energy loss (kW)	$\dot{E}_{loss, HPC} = P_{HPC, is} - P_{HPC, re}$	(7)	$\dot{E}_{loss, IPC} = P_{IPC, is} - P_{IPC, re}$	(12)
Specific energy loss (%)	$\dot{E}_{sp, loss, HPC} = \frac{\dot{E}_{loss, HPC}}{P_{HPC, re}}$	(8)	$\dot{E}_{sp, loss, IPC} = \frac{\dot{E}_{loss, IPC}}{P_{IPC, re}}$	(13)
Energy efficiency (%)	$\eta_{HPC} = \frac{P_{HPC, re}}{P_{HPC, is}}$	(9)	$\eta_{IPC} = \frac{P_{IPC, re}}{P_{IPC, is}}$	(14)

Table 2. Equations for the energy (isentropic) analysis of LPC and whole steam turbine

	LPC	Eq.	WHOLE TURBINE	Eq.
Real (polytropic) power (kW)	$P_{LPC, re} = \dot{m}_8 \cdot (h_8 - h_9) + (\dot{m}_8 - \dot{m}_9) \cdot (h_9 - h_{10}) + (\dot{m}_8 - \dot{m}_9 - \dot{m}_{10}) \cdot (h_{10} - h_{11}) + \dot{m}_{12} \cdot (h_{11} - h_{12})$	(15)	$P_{WT, re} = \sum P_{re, cylinders}$	(20)
Ideal (isentropic) power (kW)	$P_{LPC, is} = \dot{m}_8 \cdot (h_8 - h_{9is}) + (\dot{m}_8 - \dot{m}_9) \cdot (h_{9is} - h_{10is}) + (\dot{m}_8 - \dot{m}_9 - \dot{m}_{10}) \cdot (h_{10is} - h_{11is}) + \dot{m}_{12} \cdot (h_{11is} - h_{12is})$	(16)	$P_{WT, is} = \sum P_{is, cylinders}$	(21)
Energy loss (kW)	$\dot{E}_{loss, LPC} = P_{LPC, is} - P_{LPC, re}$	(17)	$\dot{E}_{loss, WT} = P_{WT, is} - P_{WT, re}$	(22)
Specific energy loss (%)	$\dot{E}_{sp, loss, LPC} = \frac{\dot{E}_{loss, LPC}}{P_{LPC, re}}$	(18)	$\dot{E}_{sp, loss, WT} = \frac{\dot{E}_{loss, WT}}{P_{WT, re}}$	(23)
Energy efficiency (%)	$\eta_{LPC} = \frac{P_{LPC, re}}{P_{LPC, is}}$	(19)	$\eta_{WT} = \frac{P_{WT, re}}{P_{WT, is}}$	(24)

4. Turbine steam operating parameters required for the energy (isentropic) analysis

Energy (isentropic) analysis of any steam turbine or any of its cylinders requires knowledge of steam specific enthalpies and mass flow rates in each operating point for the real (polytropic) and ideal (isentropic) steam expansion processes.

For the observed turbine, steam mass flow rates, pressures and temperatures in each operating point of the real (polytropic) expansion process, Fig. 1, are found in [17] and presented in Table 3. Steam specific enthalpies and specific entropies are calculated in each operating point from known steam temperature and pressure by using Nist-REFPROP 9.0 software [18]. Steam specific entropies are necessary for two reasons - for proper defining isentropic (ideal) steam expansion process through each turbine cylinder and for data validation (in real steam expansion process steam specific entropy should increase from the inlet into the first turbine cylinder until the outlet of the last turbine cylinder).

Table 3. Steam parameters in each operating point for real (polytropic) expansion (nominal turbine load)

O.P.*	Pressure (MPa)	Temperature (°C)	Mass flow rate (kg/s)	Steam specific enthalpy (kJ/kg)	Steam specific entropy (kJ/kg·K)
1	23.72	564.3	536.88	3398.6	6.2737
2	7.28	381.8	38.14	3103.4	6.3500
3	4.77	321.9	43.97	2998.7	6.3551
4	4.77	321.9	454.77	2998.7	6.3551
5	4.2	565.7	454.77	3594.5	7.2545
6	2.36	473.6	26.39	3405.7	7.2764
7	1.22	376.8	30.91	3211.2	7.2961
8	1.22	376.8	397.48	3211.2	7.2961
9	0.44	255.4	14.19	2974.2	7.3556
10	0.24	191.3	14.48	2851.1	7.3831
11	0.12	123.5	29.05	2721.7	7.3975
12	0.02	60.1	339.75	2467.5	7.4827

* Operating points (O.P.) are defined according to Fig. 1 and Fig. 2.

Ideal (isentropic) steam expansion process is a process between the same pressures and with identical mass flow rates as in the real (polytropic) one, but while retaining the same steam specific entropy [19]. As presented in Fig. 2, ideal (isentropic) steam expansion process for each turbine cylinder is defined from the cylinder inlet until the outlet, without any change in steam specific entropy during the expansion.

According to such ideal expansion process, each turbine cylinder will develop higher power (in comparison to real process), because this process did not take into account losses during steam expansion. Steam parameters in each operating point of each observed turbine cylinder, Fig. 2, during ideal (isentropic) steam expansion process are summarized and presented in Table 4.

Table 4. Steam parameters in each operating point for ideal (isentropic) expansion (nominal turbine load)

O.P.*	Pressure (MPa)	Temperature (°C)	Steam specific entropy (kJ/kg·K)	Steam specific enthalpy (kJ/kg)
1	23.72	564.3	6.2737	3398.6
2is	7.28	364.8	6.2737	3054.0
3is	4.77	305.5	6.2737	2951.0
5	4.20	565.7	7.2545	3594.5
6is	2.36	466.3	7.2545	3389.4
7is	1.22	364.3	7.2545	3184.5
8	1.22	376.8	7.2961	3211.2
9is	0.44	240.4	7.2961	2943.2
10is	0.24	172.0	7.2961	2811.6
11is	0.12	104.8	7.2961	2682.5
12is	0.02	60.1	7.2961	2405.3

* Operating points (O.P.) are defined according to Fig. 2.

5. Results and discussion

A comparison of real and ideal developed power for the whole observed steam turbine and each of its cylinders is presented in Fig. 3. The whole turbine develops real power equal to 655.35 MW; while in the ideal conditions, it could develop 716.18 MW (if in all turbine cylinders isentropic steam expansion occurs).

While observing turbine cylinders, the highest power (both real and ideal) develops LPC, while the lowest power (again, both real and ideal) will be developed in IPC. For the LPC, which is a dominant power producer, should be noted that its operating conditions are worst in comparison to other cylinders (high steam volume flow rate, occurrence of water droplets in steam for the last few stages - under the saturation line, long curved turbine blades - high centrifugal forces, etc.), therefore this cylinder should be carefully designed and maintained.

Steam re-heat process applied for the observed turbine, Fig. 1 and Fig. 2, ensures operation of the majority of LPC turbine stages in the superheated area (an area in which water droplets did not occur), therefore it surely improves turbine operation and have a positive influence on the entire power plant efficiency.

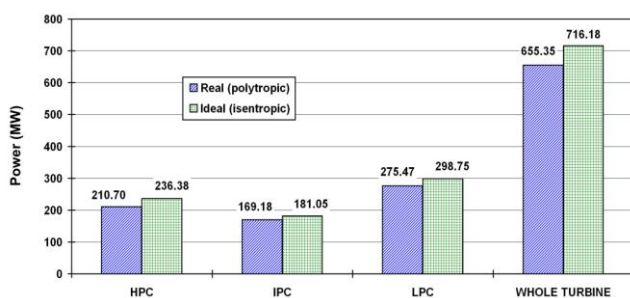


Fig. 3. Real and ideal power of each turbine cylinder and the whole turbine

Energy loss of the entire analyzed steam turbine and all of its cylinders are calculated as a difference between real (polytropic) and ideal (isentropic) power. The whole turbine energy loss equals to 60.82 MW, while when observing turbine cylinders the highest energy loss occurs in HPC (25.67 MW) and the lowest energy loss can be seen in IPC (11.87 MW), Fig. 4.

Specific energy loss of the whole turbine and all of its cylinders is obtained by dividing the energy loss with real (polytropic) developed power. This variable is similar to specific fuel consumption, which is a commonly used for defining operating conditions of internal combustion engines [20, 21]. In the case of the analyzed steam turbine and all of its cylinders, it can be concluded that the dominant value of specific energy loss occurs in HPC (12.18%), which means that HPC has the highest energy loss in regards to real developed power (significantly higher when compared to other cylinders and to the whole turbine). The lowest specific energy loss is observed for IPC (7.01%), while the whole observed steam turbine has specific energy loss equal to 9.28%.

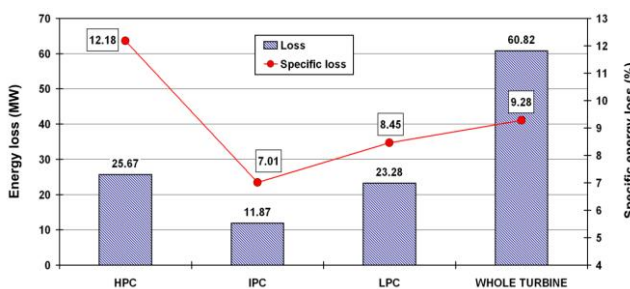


Fig. 4. Energy loss and specific energy loss of each cylinder and the whole turbine

Comparison of Fig. 4 and Fig. 5 leads to the important conclusion that for the whole observed turbine and each of its cylinders specific energy loss and energy efficiency are reverse proportional.

HPC which has the highest specific energy loss, Fig. 4, simultaneously has the lowest energy efficiency equal to 89.14%, Fig. 5, while the highest energy efficiency (93.44%) can be observed in the IPC, which has the lowest specific energy loss.

Whole analyzed steam turbine has energy efficiency equal to 91.51%. In comparison to low power steam turbines [22], turbine analyzed in this paper has a much higher energy efficiency what is expected for such high power steam turbine.

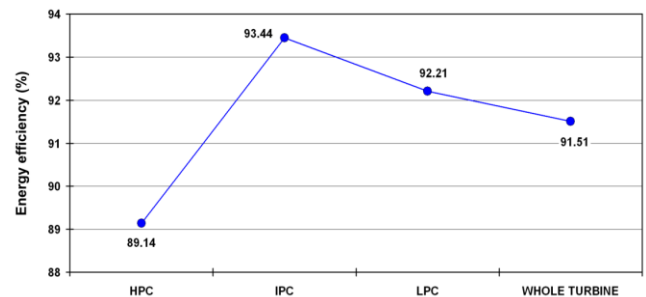


Fig. 5. The energy efficiency of each turbine cylinder and the whole turbine

6. Conclusions

The paper present energy (isentropic) analysis of three-cylinder high power steam turbine in which operation process is included steam re-heater. Comparison of steam expansion processes (ideal and real) through each turbine cylinder at nominal load leads to several notable conclusions:

- While observing turbine cylinders, the highest power (both real and ideal) develops low pressure cylinder, while the lowest power is developed in the intermediate pressure cylinder. A whole turbine at nominal load develop real power equal to 655.35 MW, while ideal (isentropic) power which can be obtained in ideal situation is 716.18 MW.
- Due to the highest steam pressures and temperatures, high pressure turbine cylinder has the highest energy loss, while the lowest energy loss occurs in the intermediate pressure cylinder. The same conclusion is valid if observing specific energy loss. The energy loss in the whole observed turbine is 60.82 MW and specific energy loss for the whole turbine is 9.28%.
- Specific energy loss of any turbine cylinder and of the whole turbine is reverse proportional to energy efficiency.
- High pressure cylinder has the lowest, while intermediate pressure cylinder has the highest energy efficiency (89.14% in comparison to 93.44%). The energy efficiency of the whole observed turbine is 91.51%, what is in the expected range for such high power steam turbines at nominal load.
- Further research and possible improvements will be firstly based on high pressure turbine cylinder and the aim will be to decrease its losses and increase its efficiency.

7. Acknowledgment

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A new method for the detection of poor electrical contacts in low-voltage electrical installations characterised by the TN protection system – field validation in residential buildings

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Abstract: The previously developed new method for detecting poor electrical contacts in low-voltage electrical installations characterised by the TN protection system has been validated by field measurements performed in residential buildings. The method was developed by the establishment of a correlation between the measured line to earth and line to neutral short circuit loop resistances and the degree of the contact deterioration, i.e. the increase of its electrical resistance. The correlation was established by analysing the data obtained from a large number of documents related to periodic verifications of the quality of low-voltage electrical installations in industrial and administrative facilities (issued by the Laboratory for testing low-voltage electrical and lightning protection installations at the School of Electrical Engineering in Belgrade), as well as the data obtained through a large number of experiments in which the impact of poor electrical contacts on the occurrence of „hot“ spots in low-voltage electrical installations was analysed. In those experiments the influence of an incomplete overlap of the surface of the copper conductor and the contact surface at the electrical component terminal (reduction of the contact surface), a reduced pressure force between the contact surfaces of the copper conductor and the screw of the electrical component terminal (reduction of the torque), and an increased oxide layer at the point of electrical contact (old and/or corrosion-damaged contact) on electrical and thermal behaviour of electrical contacts was investigated. The developed method for detecting poor electrical contacts was applied to the verification of the quality of low-voltage electrical installations in 6 flats of old (10–60 years) residential buildings and the measurement results are presented and analysed in this paper.

Keywords: POOR ELECTRICAL CONTACT, CONTACT TIGHTENING TORQUE, HOT SPOT, FIRE, CONTACT RESISTANCE, PERIODIC VERIFICATION OF LOW-VOLTAGE ELECTRICAL INSTALLATION

1. Introduction

Failures in electrical installations represent a significant fire safety problem which actively needs to be taken into consideration in many areas of human activities [1–3]. Frequent types of such failures are glowing connections and series arc, which usually occur due to overheating of poor electrical connections characterised by a high electrical resistance [4]. As in many other technical fields [5, 6], there is a constant need for innovations in the development of more efficient methods and devices in the field of electrical installations regarding fire safety. In recent studies, researchers' efforts were invested in the development of new techniques and algorithms for the detection of the occurrence of the series arc in electrical circuits [7–10], as well as to improve methods for the fault loop impedance measurement in TN low-voltage networks [11]. This paper describes a new method developed for detecting poor electrical contacts in low-voltage electrical installations characterised by the TN protection system.

Poor electrical contact is a failure in low-voltage electrical installations that cannot be detected either by procedures for periodic verification of the quality of low-voltage electrical installations defined in national and international regulations and standards or by any conventional protection device [12–14]. At the same time, it can easily and suddenly cause a hot spot or series electric arc, which are the most common causes of fires caused by failures in low-voltage electrical installations.

In an electrical installation, a poor electrical contact can be considered as characterised by [15]:

- an incomplete overlap of the surface of the copper conductor and the contact surface at the electrical component terminal (reduction of the contact surface),
- a reduced pressure force between the contact surfaces of the copper conductor and the screw of the electrical component terminal (reduction of the torque), or
- an increased oxide layer at the point of electrical contact (old and/or corrosion-damaged contact).

The effects of the reduction of the contact surface, reduction of the torque and the increased oxide layer at the point of electrical

contact on the electrical and thermal behaviour of a poor contact were experimentally and theoretically investigated in [16], [17] and [4], respectively. Based on a large number of experiments, as well as on the data obtained from a large number of documents related to periodic verifications of the quality of low-voltage electrical installations in industrial and administrative facilities (issued by the Laboratory for testing low-voltage electrical and lightning protection installations at the School of Electrical Engineering in Belgrade), a new method for detecting poor electrical contacts in low-voltage electrical installations characterised by the TN protection system has been developed and presented in [4] and [15]. The developed method was applied to the verification of the quality of low-voltage electrical installations in 6 flats of old (10–60 years) residential buildings and the measurement results are presented and analysed in this paper.

2. Development of a new method for detecting poor electrical contacts in low-voltage electrical installations characterised by the TN protection system

2.1 The basic idea for the development of a new method for detecting poor electrical contacts

The current standard procedure for the verification of the quality of low-voltage electrical installations [18] is based on the comparison of the measured line to earth resistance with the limit value which enables sufficiently fast tripping of the corresponding protection device (in order to prevent electric shock) [19]. Since the limit values are high, all of the electrical circuits where the measured line to earth resistance is lower than the limit value (R_{sMAX}) are declared as in order, although some of them may contain a poor contact.

The idea was to develop a procedure for detecting poor contacts in receptacles, based on measuring both the line to earth and line to neutral short circuit loop resistances during periodic verification of low-voltage electrical installations. The detection of a noticeable increase of the earth fault loop and/or line to neutral short circuit loop impedance indicates the existence of at least one poor contact in the observed electrical circuit.

According to [20], the usually applied (conventional) measuring equipment for verifications of low-voltage electrical installations enables the measurement of both of those impedances. Schematic presentations of the earth fault loop (L-PE) and line to neutral short circuit loop impedance (R_{SL-N}) measurements using a conventional measuring device are given in Figs. 1 and 2, respectively.

The line to earth resistance (R_{SL-PE}) in the TN system consists of the resistance of the power transformer's secondary winding, phase conductor resistance between the power transformer and the test location, and equipment grounding conductor resistance between the test location and the power transformer. The line to neutral short circuit loop resistance (R_{SL-N}) in the TN system consists of the resistance of the power transformer's secondary winding, phase conductor resistance between the power transformer and the test location, and neutral conductor resistance between the test location and the power transformer.

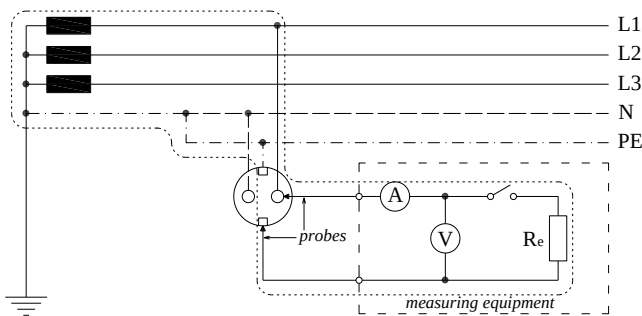


Fig. 1 Schematic presentation of measuring R_{SL-PE} using conventional measuring equipment (R_e represents the internal electrical resistance of the measuring equipment).

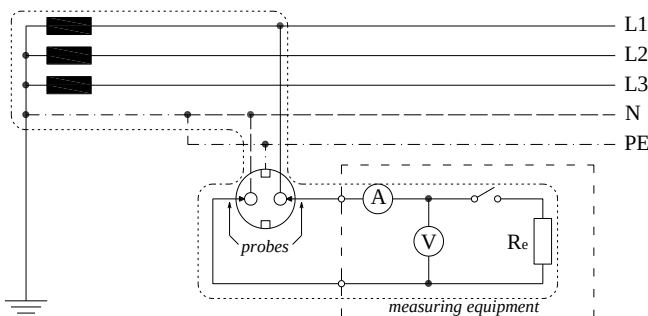


Fig. 2 Schematic presentation of measuring R_{SL-N} using conventional measuring equipment.

2.2 The data obtained from a large number of documents related to periodic verifications of the quality of low-voltage electrical installations

As reported in [4], the results of periodic verifications of low-voltage electrical installations performed by the Laboratory in public and commercial buildings with a total area of over 150,000 m² were analysed. The measured R_{SL-PE} values for 11,159 receptacles were statistically analysed and their statistical distribution is given in Fig. 3, which shows the number of receptacles for which the measured R_{SL-PE} resistances belonged to each of the ranges 0–0.1 Ω , 0.1–0.2 Ω , ..., 1.1–1.2 Ω and 1.2–1.3 Ω . The number of the receptacles for which the R_{SL-PE} resistance was higher than 1.3 Ω (1.5% of their total number) are not shown in Fig. 3, because their resistances were scattered within the range 1.31–7.68 Ω .

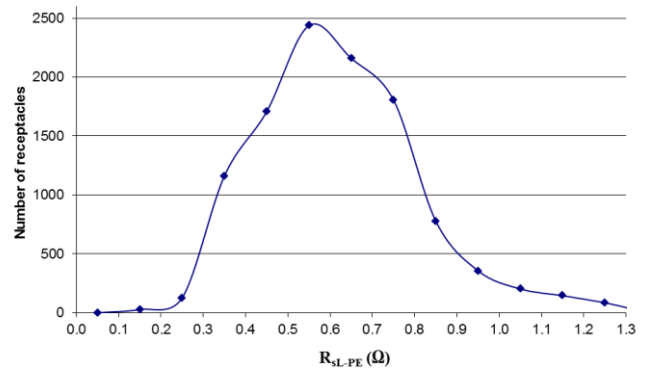


Fig. 3 Number of receptacles for which R_{SL-PE} belonged to each of the ranges 0.1 Ω wide. [4]

It was noticed in [4] that the majority of the measured R_{SL-PE} resistances belonged to the range 0.3–1 Ω , emphasising that the values lower than 0.3 Ω were measured in cases where the MV/LV transformer station was positioned inside the building or in its vicinity and for electrical circuits on lower floors of the building, while the values higher than 1 Ω were measured for electrical circuits on upper floors, because R_{SL-PE} increases with the distance between the electrical circuit and the transformer station.

It was also reported in [4] that on 82 receptacles R_{SL-PE} resistances higher than the corresponding R_{SMAX} values were measured (in those receptacles the R_{SL-PE} resistances ranged from 1.79 Ω to 7.68 Ω). These circuits were declared as inappropriate for use, because the conditions for the prevention of an electric shock were not met. In addition, apart from the 11,159 receptacles for which R_{SL-PE} values were measured, there were 84 receptacles where the interruption of the equipment grounding conductor was detected, which were also declared as inappropriate for use. After tightening all electrical contacts in those 166 receptacles (or after replacing the receptacles), as well as tightening all electrical contacts in the supplying distribution boards, the R_{SL-PE} resistances were measured again and in all cases their values were not only lower than R_{SMAX} , but also lower than 1.3 Ω .

However, as reported in [4], in addition to the 166 receptacles with failures detected by the standard procedure, there were additional 84 receptacles where the R_{SL-PE} resistances were lower than R_{SMAX} , but high enough to indicate the presence of at least one poor contact (in those receptacles R_{SL-PE} resistances ranged from 1.3 Ω to 4.38 Ω). According to the standard procedure, although they represent the potential cause of fire, electrical circuits containing those receptacles would have been declared as in order. Nevertheless, the users of the facilities were instructed to make the necessary repairs, and after tightening all electrical contacts, in all of those cases the measured R_{SL-PE} resistance was lower than 1.3 Ω . Apart from the additional 84 receptacles, the poor contacts were also found in receptacles where R_{SL-PE} was lower than 1.3 Ω , but over 0.5 Ω higher than the R_{SL-PE} resistances measured on the surrounding receptacles.

2.3 The data obtained through a large number of experiments

As previously mentioned, the effects of the reduction of the contact surface, reduction of the torque and the increased oxide layer at the point of electrical contact on the electrical and thermal behaviour of a poor contact were experimentally and theoretically investigated in [16], [17] and [4], respectively.

The basic idea for all of the conducted experiments was to create various types of contacts which can be found in low-voltage electrical installations, to establish typical currents (they ranged from 2 A to 25 A in the conducted experiments) in circuits containing the created contacts, and to observe the time-varying

values of the electrical resistance, temperature, dissipated power and voltage of the created contacts. Various types of contacts were created using various combinations of materials (copper–copper, copper–brass and copper–stainless steel), solid and stranded wires with various cross-sections (1.5 mm², 2.5 mm² and 4 mm²), various percentage of the overlapping area of the electrodes forming the contact (100%, 50% and 15%) and various adjusted torques on the other wire screw terminal connection in receptacles and plugs (1 Nm (very good contact), 0.2 Nm (poor contact), or 0.1 Nm (very poor contact)). In addition, contacts with various types of increased oxide layer at the point of electrical contact were used in experiments. Experiments were performed on a receptacle that has been used for many years (30 years in the analysed case), as well as on new receptacles, the electrical contacts of which were intentionally exposed to corrosion prior to the experiments. The experimental setup and used measuring equipment are shown in Fig. 4.

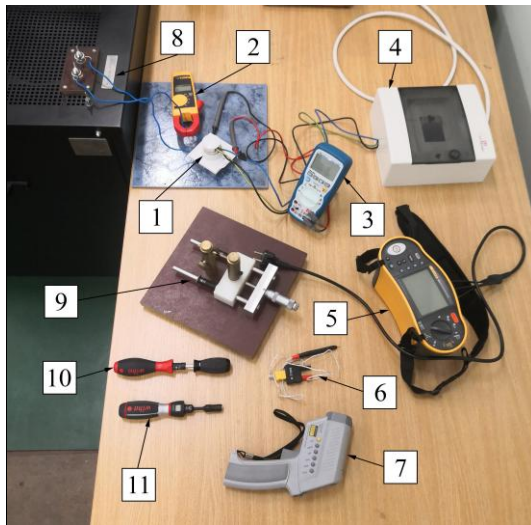


Fig. 4 Experimental setup (1 – tested receptacle, 2 – clamp meter FLUKE 323, 3 – digital multimeter PeakTech 3360, 4 – plastic switchboard, 5 – installation tester instrument FLUKE 1653B, 6 – type-K (Chromel/Alumel) thermocouple probe, 7 – infrared thermometer Cole-Parmer, 8 – resistance decade box 230 V, 60 A, 9 – the apparatus providing the adjustment of the overlapping area of the electrodes, 10 – mechanical torque screwdriver Wiha TorqueVario-S26462, and 11 – digital torque screwdriver TSD-50).

Analysing the results of the conducted experiments, it was concluded that copper–stainless steel represents a critical combination of materials for which a contact most rapidly reaches the maximum permissible temperature under the same conditions (the same load, conductor cross-section and contact deterioration degree in terms of the same percentage reduction of the overlap surface) [16]. In addition, it was concluded that poor electrical contacts developed in built-in electrical installations of buildings (where the copper conductor of the full cross-section is common) are more unfavourable for the occurrence of a „hot“ spot compared to poor electrical contacts developed in power cables of electric loads (where the stranded copper conductor is commonly used) [17]. It was shown in [17] that poor contacts with the electrical resistance ranging from 80 mΩ to 250 mΩ represent a threat to safety if the circuit current is high (the current of 16 A, limited by the applied protection device, generally represents the maximum rated current in electrical circuits installed in residential, commercial and public buildings connected to the mains with the rated voltage of 230 V). Taking into account all data obtained from periodic verifications of the quality of low-voltage electrical

installations, as well as all data obtained through experiments, it was concluded in [4] that the limit for the R_{SL-PE} resistance (indicating that there is at least one poor contact in an electrical circuit) (R_{lim}) should be 0.5 Ω higher than the highest R_{SL-PE} resistance measured on the surrounding receptacles when doing periodic verification of low-voltage electrical installations.

3. A new method for detecting poor electrical contacts in low-voltage electrical installations

The measurements of R_{SL-PE} and R_{SL-N} , followed by a comparison of their values to R_{lim} and the analysis based on Tables 1–3, represent a new method for detecting poor contacts in low-voltage electrical installations developed and presented in [4] and [15].

Tables 1 and 2 contain the maximum line to earth resistances that ensure effective tripping of the protection device in case of failure in the TN system (R_{sMAX}), determined for the most frequently applied fuse-links (both fast and slow) and miniature circuit breakers (MCB) of types B and C (with the rated currents (I_r) of 6–25 A), respectively. In all cases, the value of R_{sMAX} was obtained by dividing the value of the rated mains voltage (230 V) with the corresponding value of I_a (the minimal current for which protection device operates within 0.4 s (a condition given in [19])). For each of the considered fuse-links the value of I_a was adopted from the corresponding fuse-link overheating characteristic [21]. According to [22], the minimal MCB currents (I_a) for which the fuse-links react within 0.1 s (and, therefore, within 0.4 s) amount to 5 I_r and 10 I_r for types B and C, respectively.

Table 3 contains guidelines for potential locations of poor contacts and possible fire hazards in all situations which can occur in practice. It should be applied when the measured R_{SL-PE} resistance is lower than R_{sMAX} (in the opposite case, the corresponding circuit should be declared unsafe).

Therefore, by measuring R_{SL-PE} and R_{SL-N} values in every circuit followed by a comparison of their values to R_{lim} and the analysis based on Tables 1–3, it can be determined if there is a poor contact in the circuit.

Table 1: Values of I_a and R_{sMAX} for fast and slow fuse-links ($I_r = 6–25$ A) [4]

I_r (A)	I_a (A)		R_{sMAX} (Ω)	
	Fast	Slow	Fast	Slow
6	16.71	29.65	13.76	7.75
10	34.08	55.65	6.74	4.13
16	51.07	86.86	4.50	2.64
20	67.62	110.01	3.40	2.09
25	94.69	138.13	2.42	1.66

Table 2: Values of I_a and R_{sMAX} for MCBs of types B and C ($I_r = 6–25$ A) [4]

I_r (A)	I_a (A)		R_{sMAX} (Ω)	
	Type B	Type C	Type B	Type C
6	30	60	7.67	3.83
8	40	80	5.75	2.87
10	50	100	4.60	2.30
13	65	130	3.53	1.76
16	80	160	2.87	1.43
20	100	200	2.30	1.15
25	125	250	1.84	0.92

Table 3: Loop resistance analysis in cases in which the measured R_{SL-PE} resistance is lower than the maximum value of the line to earth resistance ($R_{S\text{MAX}}$) which ensures efficient tripping of the protection device [4]

	$R_{SL-PE} < R_{lim}$	$R_{SL-PE} > R_{lim}$	$R_{SL-PE} < R_{lim}$	$R_{SL-PE} > R_{lim}$
	$R_{SL-N} < R_{lim}$	$R_{SL-N} < R_{lim}$	$R_{SL-N} > R_{lim}$	$R_{SL-N} > R_{lim}$
Location of a poor electrical contact	The electric circuit probably has no poor electrical contact	Poor electrical contact on the equipment grounding conductor	Poor electrical contact on the neutral conductor	– poor electrical contact on the phase conductor, or – poor electrical contacts on two conductors (all three combinations are possible), or – poor electrical contacts on all three conductors (the worst case)
Fire hazards (consequences of malfunction)	Probably do not exist	None (in case of failure, the protection device responds within the safe interval)	Possible, due to a hot spot on the neutral conductor	Possible, due to a hot spot on the phase and/or neutral conductor (in case of failure, the protection device responds within the safe interval)

Table 4: Results of measurements obtained during verifications of the quality of low-voltage electrical installations in flats of residential buildings of different ages (10–60 years) using the new method. * Note: Values of the measured resistance *before/after* the intervention of an electrician and removal of failure.

No. of flat	Building age (years)	Measurement	No. of receptacle									
			1	2	3	4	5	6	7	8	9	10
1	10	$R_{SL-PE} (\Omega)$	0.47	0.46	0.48	0.47	0.48	0.49	0.50	0.49	0.48	0.48
		$R_{SL-N} (\Omega)$	0.45	0.45	0.47	0.46	0.46	0.47	0.48	0.47	0.46	0.46
2	10	$R_{SL-PE} (\Omega)$	0.49	0.46	0.48	1.23!/0.49*	0.48	0.49	0.48	0.49	0.51	0.50
		$R_{SL-N} (\Omega)$	0.49	0.47	0.48	0.47	0.47	0.48	0.47	0.48	0.47	0.48
3	20	$R_{SL-PE} (\Omega)$	0.34	0.35	0.36	0.36	0.38	0.35	0.37	0.39	0.38	0.36
		$R_{SL-N} (\Omega)$	0.33	0.32	0.33	0.35	0.34	0.34	0.33	0.34	0.35	0.35
4	20	$R_{SL-PE} (\Omega)$	0.44	0.43	0.44	0.44	0.43	1.34!/0.43*	0.42	0.44	0.46	0.45
		$R_{SL-N} (\Omega)$	0.44	0.42	0.43	0.44	0.42	1.33!/0.44*	0.41	0.43	0.45	0.44
5	45	$R_{SL-PE} (\Omega)$	1.28!/0.60*	0.65	0.64	0.61	0.60	0.61	0.60	0.60	0.59	0.58
		$R_{SL-N} (\Omega)$	0.58	0.59	0.63	0.59	0.60	0.58	0.57	0.58	0.58	0.55
6	60	$R_{SL-PE} (\Omega)$	0.50	0.48	0.47	0.49	0.48	0.47	0.50	0.47	0.48	0.50
		$R_{SL-N} (\Omega)$	0.48	0.46	0.46	0.48	0.45	0.44	0.49	1.41!/0.45*	0.44	0.49

4. Results and discussion

In order to validate the described new method for detecting poor contacts in low-voltage electrical installations, it was applied to the verification of the quality of low-voltage electrical installations in 6 flats of old (10–60 years) residential buildings. All of them were characterised by the TN protection system. In each of the flats 10 receptacles were examined (R_{SL-PE} and R_{SL-N} values were measured for each of them). The measurement results are given in Table 4.

Note that all of the examined electrical circuits were protected either by slow fuse-links with the rated current of 16 A ($R_{S\text{MAX}} = 4.50 \Omega$) or by MCBs of type B with the same rated current ($R_{S\text{MAX}} = 2.87 \Omega$). All measured R_{SL-PE} and R_{SL-N} values for the 60 examined receptacles were lower than $R_{S\text{MAX}}$ and, therefore, according to the standard procedure electrical circuits containing those receptacles would have been declared as in order. However, the comparison of the measured R_{SL-PE} and R_{SL-N} with R_{lim} (the resistance 0.5Ω higher than the highest R_{SL-PE} (R_{SL-N}) resistance measured on the surrounding receptacles) showed that there were poor electrical contacts in 4 receptacles representing a potential cause of fire. When the new method was applied, poor electrical contacts were detected on the equipment grounding conductors in receptacles No. 4 in flat No. 2 and No. 1 in flat No. 5, on the neutral conductor in receptacle No. 8 in flat No. 6 and on the phase conductor in receptacle No. 6 in flat No. 4. After the electrician replaced those 4 receptacles with new ones, R_{SL-PE} and R_{SL-N} were remeasured in those electrical circuits in order to check if their new values met the conditions for safe protection against electric shock in case of failure. The remeasured values showed that in all 4 cases the defects which caused poor electrical contacts were eliminated by the intervention of an electrician, as well as that the replacement of those 4 receptacles with new ones was justified.

5. Conclusion

A new method for detecting poor contacts in low-voltage electrical installations characterised by the TN protection system, based on the measurement of both the R_{SL-PE} and R_{SL-N} resistances

and their comparison to R_{lim} (the resistance 0.5Ω higher than the highest R_{SL-PE} (R_{SL-N}) resistance measured on the surrounding receptacles) is presented. The new method was applied to the verification of the quality of low-voltage electrical installations in 6 flats of old (10–60 years) residential buildings and the measurement results are presented and analysed. According to the standard procedure, all of the 60 examined electrical circuits would have been declared as in order. However, the application of the presented method showed that there were poor electrical contacts in 4 receptacles, which represented the potential cause of fire. After the intervention of the electrician the defects which caused poor electrical contacts were successfully eliminated.

The application of the new method when verifying the state of electrical contacts would considerably reduce the probability of the occurrence of dangerous hot spots. This would solve the problem of the inability to detect hot spots by infrared thermography in cases where there is no visual contact. However, it should be emphasised that the application of the new procedure is limited to the TN system, which is the most frequently applied protection system.

6. Acknowledgements

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7. References

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