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THE CONCEPT OF QUALITY MANAGEMENT MODELING IN THE CONTEXT OF STRUCTURING ORGANIZATIONAL PROBLEMS

The article examines the main factors to ensure effective organization of production in the process of improving product quality; analytically assessed the level of quality assurance of industrial production in Ukraine; identified typical problems of domestic engineering that influence the effectiveness of quality systems; defined the compliance of the quality system of the enterprise as a means of implementing quality policy; formulated the basic provisions of the organizational and economic mechanism of product quality management; structured organizational problems and formed the concept of the main stages of ensuring the effective functioning of the quality management mechanism at the enterprise. The modern organizational and economic mechanism should include statistical methods of quality management for rapid response of the central quality management system to problems arising during the production process, provide analysis of quality and causes of defects, develop effective impact on various factors affecting quality, and implement them in the management process. Accordingly, the organizational and economic mechanism is the genesis of quality management systems being an interconnected system of organizational, economic and legal methods and levers of management which in conjunction ensure the implementation of comprehensive targeted programs and plans to improve product quality; it should provide systematic control, accounting, assessment of the work quality and economic incentives for the staff. The improvement of the mechanism should be carried out in close connection with the ISO 9000 standards, market research and the level of economic, technical and human capacity of the enterprise. The process model of organizational and economic support of quality management of mechanical engineering products is offered taking into account requirements of economic laws and laws of development of practice of quality management. The practical significance of the obtained results is determined by the relevance of the tasks and the specific focus on the formation of organizational and methodological mechanism to improve product quality management at domestic engineering enterprises.

Key words: modeling, quality management, competitiveness, industrial production, standards, production process.

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КОНЦЕПЦІЯ МОДЕЛЮВАННЯ МЕНЕДЖМЕНТУ ЯКОСТІ В УМОВАХ СТРУКТУРУВАННЯ ПРОБЛЕМ ОРГАНІЗАЦІЇ

У статті досліджено фактори забезпечення ефективної організації виробництва у процесі вдосконалення якості продукції; аналітично оцінено рівень забезпечення якості промислової продукції в Україні; виокремлено типові проблеми вітчизняного машинобудування, які впливають на ефективність систем якості; визначено відповідність системи якості підприємства як засобу реалізації політики у сфері якості; сформульовані принципи положення організаційно-економічного механізму управління якістю продукції; структуровано організаційні проблеми та сформульовано концепцію основних етапів забезпечення ефективного функціонування механізму управління якістю на підприємстві.

Ключові слова: моделювання, менеджмент якості, конкурентоспроможність, промислова продукція, стандарти, виробничий процес.

Problem statement. The process of globalization in the economy intensifies competition, as the market expansion allows consumers to choose products from almost all global manufacturers. The central place in industrial product quality assurance systems is taken by the organizational and economic mechanism of quality management which, by means of its elements, provides their reliable functioning. In today's conditions of increased competition, turning it into a global principle of the survival and success for the enterprise, the foundation of machinery engineering stable position on the market is the timely offer of products that meets international standards because the trend of global economic internationalization is among the main tendencies of the modern economy. The quality system of industrial products should take into account the characteristics of the enterprise, minimize the cost of product development and provide its implementation. The relevance of the subject is due to the need to increase the competitiveness of domestic industrial enterprises through the modeling of organizational and economic mechanism, which will help to objectively identify the root causes and factors to ensure effective functioning of quality management processes, quality status and their consideration in the system of management decision support.

Recent research. At present, the main reasons that determine the need to improve and ensure quality include the following: growing production and social needs; increasing STP rates in the development of science, technology, manufacture, economy; improving the design of machine-building products and increasing the importance of the functions performed [1]. Among the negative factors the following should be mentioned: low labor and business discipline; insufficiently organized technical control; excessively large share of physically worn equipment; insufficient use of modern quality management methods.

In modern conditions of escalating competition as well as its transformation into a global principle of the enterprise's survival and success, the basis of the stable position of the machine-building enterprise in the market is timely supply of products that meet world quality, as internationalization is among the main trends of modern

economy. Engineering enterprises under their transition to market economy have faced the competition with foreign companies. As a result, the problem of improving product quality and its compliance with international standards has become very acute.

The quality system is important when negotiating with foreign customers who consider it necessary for the manufacturer to have a quality system and a certificate issued by an authoritative certification body [2]. The quality system should take into account the characteristics of the enterprise, minimize the cost of product development and its implementation. The quality management system, functioning at enterprises and built on the basis of international standards, ensures competitiveness not only in domestic but also in foreign markets. [3]. Developing and introducing a quality management system at a machine-building enterprise makes it possible: 1) to streamline the work of structural units, improve the relationship of employees; 2) to increase the responsibility of senior and middle staff; 3) to improve labor discipline; 4) to increase the effectiveness of engineering production; 5) to improve the quality and competitiveness of products and open access to international markets [1].

The purpose of this article is to assess the quality assurance indicators of domestic industrial production and to determine the concept of modeling organizational and economic mechanism of quality management for enterprises in this industry.

Materials and results. To study cause-and-effect relationship between the quality indicator and the elements of the production process, the main factors relevant to the problem under consideration were identified, and a graphical scheme of the model of industrial product quality assurance was constructed (Fig. 1).



Fig. 1. Model of ensuring effective organization of production at the micro level under the influence of globalization factors [proprietary design]

The following factors are considered to be the main ones influencing the organization of the production process.

1. Production (technical and organizational) factors. The implementation of these factors should be carried out through the organization of continuous improvement of production processes and the organization of a system of motivation, self-improvement, training, which providing the workforce with quality assurance methods. In this respect, it is also important to consider the function of economic losses not as a separate process, but as a stage

in the stream of creating the value of lean production. The value stream should include all the enterprises involved in the supply chain. It addresses one of the main goals of creating lean production - reducing costs and saving resources while improving the quality of products (Fig. 2).

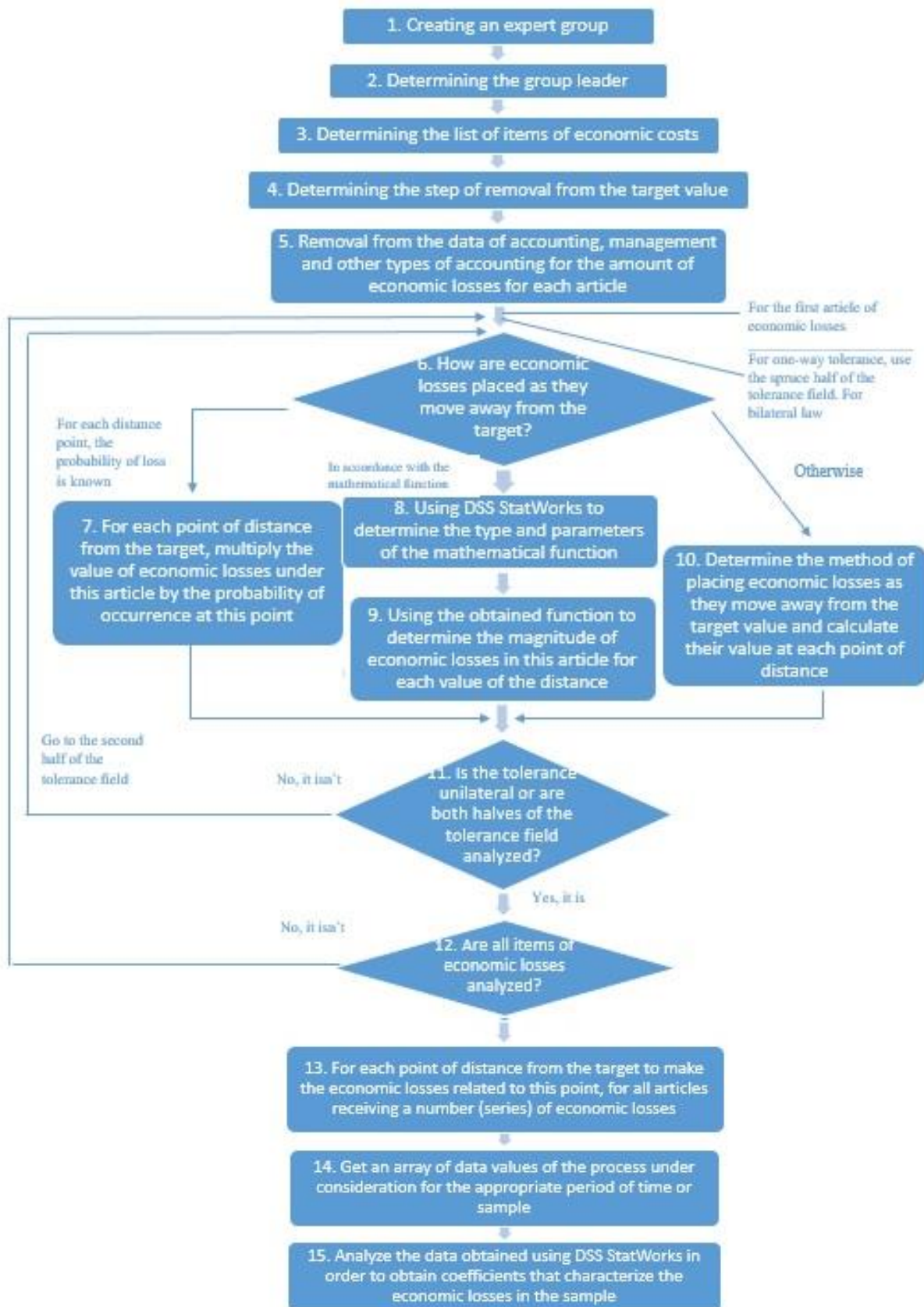


Fig. 2. Algorithm for data collection to determine the function of economic losses in the process of quality assurance

2. Investment and innovation factors. When creating an effective product quality management system, it is advisable to evaluate investments and innovations as a "growth point", i.e. to assess the investment and innovation attractiveness of the enterprise which products are analyzed. The machine-building complex needs a targeted program of innovative activities based on existing human, technological and production potentials, the increase of which requires significant investment funds. It is impossible to solve the problem of technological modernization of mechanical engineering industry in the country without governmental support. The future of the country's industrial production as a whole depends on the active participation of the state in the formation and implementation of the strategy for the development of domestic engineering production [4]. The combination of presented factors and conditions for ensuring the quality of industrial products in their relationship and interaction makes up a system of elements affecting the production competitiveness. This system of elements is in close cooperation with the processes of globalization of economic relations.

3. Globalization processes. Globalization has a great impact on production, investments in physical and human capital, the growth rate of direct foreign investment, technology, technological innovations and their dissemination from one country to another. This is due to the growing competition it causes. Technology, in turn, is a driving force for globalization itself. All these impact on the efficiency of the production quality assurance system and the competitiveness of individual products. Globalization processes include: rapid and large-scale dissemination of new technologies; transition to new technological methods of production; unification of transport and communication means, which ensures the rapid spread of goods and resources; elimination of barriers to the movement of goods, capital.

One of the important advantages of globalization processes is the economy of scale, which can potentially lead to a focus on manufacturing better competitive science-intensive products. In accordance with the above factors that affect the efficiency of the production process, the product quality assurance system should be considered in inseparable connection with all systems of the enterprise at the macro and micro levels. The problem of improving the quality and competitiveness of products can be solved by increasing the investment and innovation activities of machine-building production. Statistical data [5] (Table 1) show that during 2015-2019, in general, there is the growth of capital investment in mechanical engineering. Only in 2019 the amount of investment in the sector decreased in comparison with 2018 by 7.5 % (11,958,7 mln. UAH in 2018, 11058.0 mln – in 2019). Thus, the lack of investment delays solving the problem of replacing obsolete and worn-out equipment and technology.

Table 1

Capital investments in industry and mechanical engineering for 2015–2019 (based on [5])

	Mechanical Engineering		Industry	
	mln. UAH	in % to the previous year	mln. UAH	in % to the previous year
2015	6293,7	-	84168,0	-
2016	7166,0	113,9	108635,2	129,1
2017	9834,6	137,2	136490,1	125,6
2018	11958,7	121,6	179718,3	131,7
2019	11058,0	92,5	231849,5	129,0

Of all the factors influencing the quality of industrial products, the following main ones were identified: the level of logistics, the workers' labor quality, the level of manufacturing process management, the quality of raw materials and the level of quality control. Planning and implementation of innovative activities of industrial enterprises requires constant analysis of internal and external environment to form the need for investment, search for their sources, development and implementation of innovative projects, which will further contribute to the formation of a high level of competitiveness of industrial enterprises [6]. Thus, the condition for the formation and maintenance of qualitative and quantitative transformations of the system are innovations, and to ensure optimal and stable development it is necessary to create an investment and innovation mechanism to ensure competitiveness (Fig. 3).

Solving the problem of effective quality management of industrial products is of particular practical interest on the example of PJSC "Kryukovsky Railway Car Building Works". The company's policy in the field of quality assurance is aimed at maximum satisfaction of consumer demands and is based on comprehensive compliance with the national and international quality standards, on the certification of production and all types of products. The management system of the enterprise is certified according to the requirements of the international standard ISO 9001: 2015, the international standard ISO TS 22163: 2017, the national standard DSTU ISO 9001: 2015. The company also has quality certificates UkrSEPRO, Certification System of Federal Railway Transport (CSFRT), TR TS, European standard for environmental protection, all necessary licenses and permits for the right to manufacture and supply products [7]. Accordingly, product quality management is carried out at all stages of the product life cycle, ranging from marketing research to product consumption. This system has been created as a means of implementing the enterprise's policy in the field of quality, the main goal of which is stable and effective operations through the quality of products and the satisfaction of customers. The goal is realized by performing the following tasks: developing mutually beneficial cooperation with suppliers; attracting new customers; gaining the trust of customers; continuous improving the production and management aimed at manufacturing defect-free products;

establishing a creative environment in the team to involve each employee in the process of continuous quality improvement. The quality management system at the PJSC "KVBZ" is applied to almost all departments and services of the enterprise. This provides for a fast respond to difficulties and failures that occur during the production process, quickly detect and correct the non-compliance with the international standard ISO 9001: 2015. There are some problems in this area – namely, the need to improve the progressivity of logistics, to improve the technical readiness of technological equipment, tools, to improve the labor quality of workers and promote their more effective high-quality performance. It is necessary to strengthen the quality control of raw materials, materials, technology, production and to ensure comprehensive product quality control at each stage of the production process. A particularly important problem in the industry is the practical lack of research in the field of creating new effective technologies in recent decades. This situation is due to the reduction of workers who are highly qualified in scientific and engineering fields, the lack of a full research base [8]. The implementation of these measures should contribute to developing an effective quality management system at the enterprises of the machine-building industry.

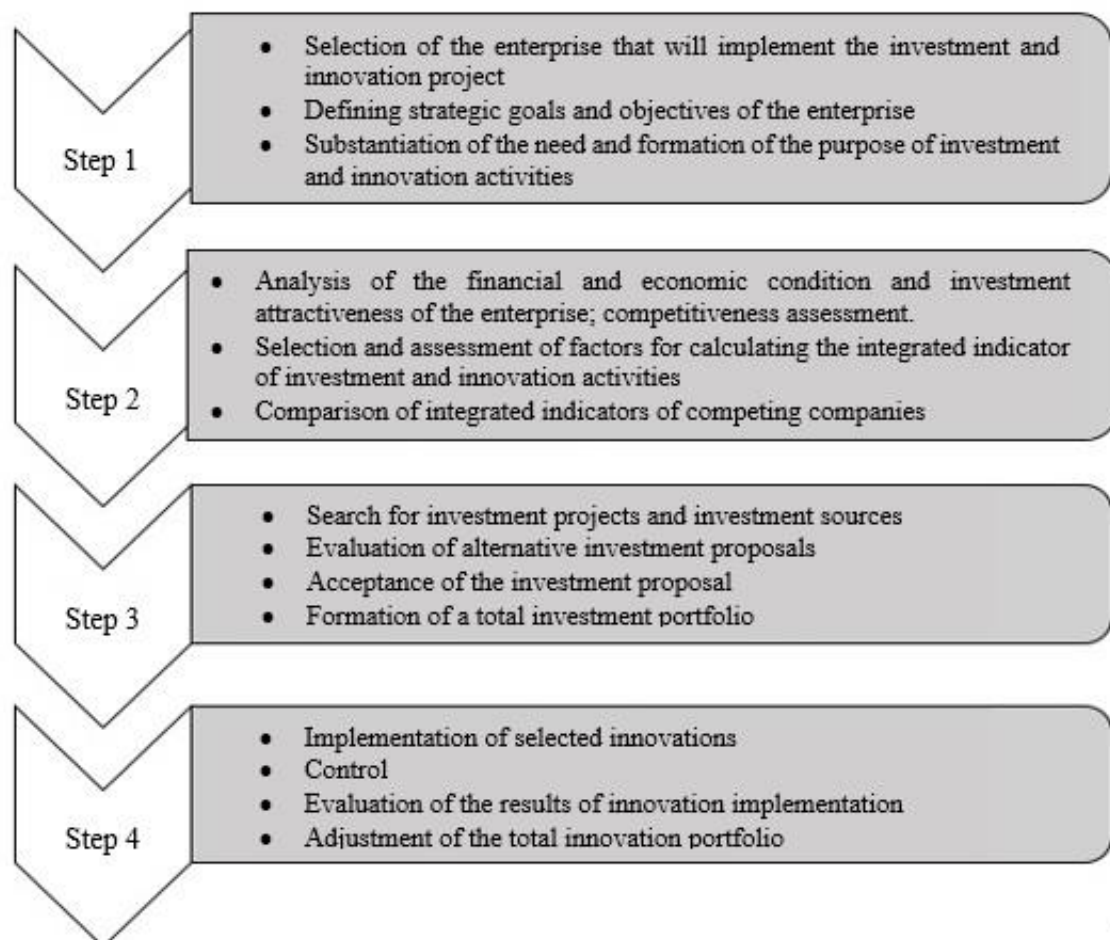


Fig. 3. The mechanism of investment and innovation activities to ensure the competitiveness of industrial enterprises [6]

The organizational and economic mechanism of quality management is in the focus of the quality assurance systems for industrial products. The mechanism is necessary to put control systems into the operation, and with its elements it ensures their reliable functioning – planning, product quality control, accounting and analysis of production fault, defects. Organizational and economic mechanism of product quality management is a set of interconnected organizational, economic, administrative and legal and other levers and methods of targeted influence on the object of management to ensure the reliable operation of the quality management system. This mechanism should provide for analyzing the quality and causes of defects, developing effective impact on various factors affecting the quality, and introducing them in the management process. In accordance with the above definition, the quality management mechanism should be considered in inseparable connection with the quality management system where this mechanism will be a central link.

One of the central components of the mechanism should be a quality management body that performs planning, control and other functions of product quality management, relying on the staff, the methods of management, quality control and analysis on the basis of regulatory framework (ISO 9000) and other economic and legal levers. A very important element of the mechanism is the promotion of quality assurance, which provides

systematic controlling, accounting, analysing and appropriate regulating of the quality. The basis of its functioning is the management system focusing on the end result, which activates the system as a whole and makes it possible to achieve its main objectives with the least cost of resources. To develop and ensure the functioning of the quality management mechanism, the following principles should be taken into account:

1. Continuous upgrading the qualification and competence of the staff at the company's marketing department, training in methods of monitoring and planning of production process quality.

2. The quality management mechanism should be a structural element of the existing quality management system, which provides for the reflection of the results of all logistics processes in the relevant quality documentation, i.e. in the internal audit reports.

3. The structure of the quality management mechanism should comply with the principle of the process approach, the application of which involves the organization of interfunctional (integrated) quality management [9]. Given the above, the following stages of formation and functioning of the organizational and economic mechanism of quality management are described. A general outline of the process model of organizational and economic mechanism to provide product quality assurance is given on Fig. 4.

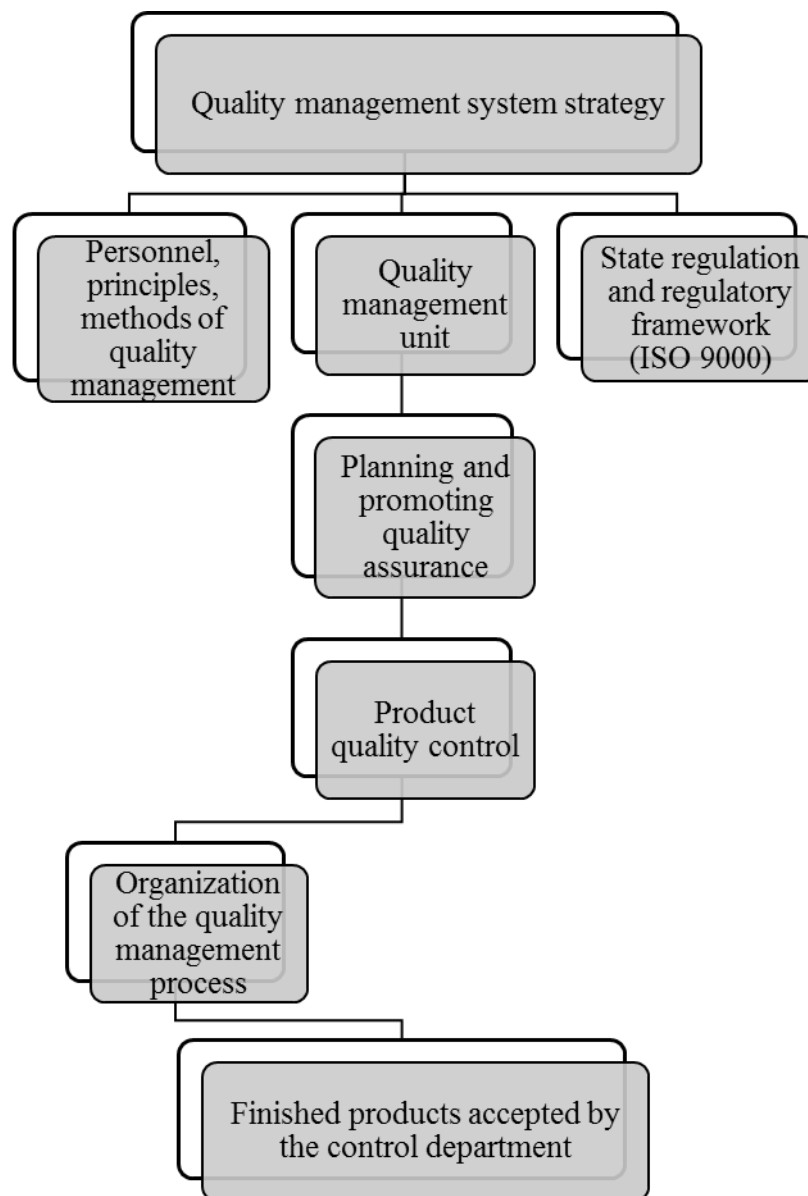


Fig. 4. Process model of organizational and economic mechanism of product quality assurance. [proprietary design]

Stage 1 – analysis of the achieved level of product quality and management. Analysis and objective assessment of the actual level of quality and defects, as well as the effectiveness of measures allows to identify problems in the area of quality assurance, if any, and to decide on the need to create a quality management system or to improve the existing production and quality management system. Particular attention should be paid to assessing the achieved level of quality based on calculating the defect level, establishing the size of the allowable defect, its

causes and nature, trends and analysis of factors affecting product quality, because the factor analysis can identify weaknesses in control and product quality assurance.

To determine the type of defects that cause the largest number of defective products, the statistical quality management methods are used, in particular a Pareto chart. According to this method, the focus on small, but vital factors provides the greatest effect. The Pareto principle is described as a 80/20 rule: 80 % of problems arise as a consequence of 20 % of all possible causes. The Pareto chart is a type of bar chart that is used to visualize factors in the descending order of importance.

While working with the Pareto chart the following steps should be taken: collecting the necessary information; analyzing causes and results; determining the significance of the obtained data. At the first stage of work we collected data on defects of machine-building products, by filling in special sheets of defect registration (Table 2).

Table 2

Defect registration checklist

№ of defect	Type of defect	Number of defects	Ratio of defects $m/\Sigma m$
1	Deformation	5	0,11
2	Scratches	24	0,56
3	Cracks	6	0,14
4	Stains	8	0,19

The following calculations were carried out: the total number of defects is determined; the relative frequency of each defect is determined. In sum, all relative frequencies should be 1,0. The obtained results allow us to solve the problem – to determine the most common defects in the machinery engineering production. Next, we built a bar chart, the columns of which correspond to the number of each defect (Fig. 5). According to the obtained data, a cumulative curve was constructed, which shows an increasing proportion of the first, second and other defects.

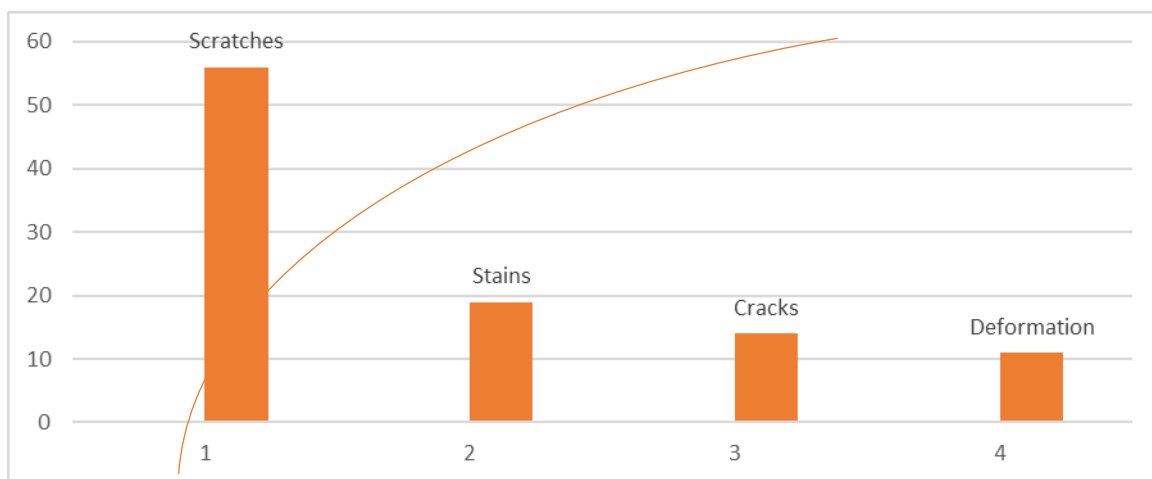


Fig. 5. The Pareto chart for mechanical engineering [proprietary design]

The Pareto chart shows that the "scratch" defect is 56 %, the "stain" defect – 19%, cracks – 14 %, deformation – 11 %. Let's call the group consisting of such defects as "stains" and "cracks" as Group B. Group A – scratches. Group C – deformation. Group A includes the most significant defects (56 %). Group B – stains and cracks – is an intermediate group (33 % of the total number of defects). Group C – other defects, the share of which is insignificant in comparison with the total number (11 %). The analysis shows that first and foremost it is necessary to strictly control the appearance of defects belonging to Group A. Using statistical methods of quality management, in particular the Pareto method, manufacturers can identify the most common defects and focus on avoiding them. Defects that are less frequent can be fixed later. This work organization and planning to avoid failures will be more productive for enterprises and will bring high economic effect.

Stage 2 – defining the goals and objectives of quality management. An important place in developing a quality management system is the definition of specific goals and objectives of quality management, as the correctly chosen goal determines the structure of the management system, its efficiency and effectiveness in the process of functioning. Depending on the assessment of the achieved level of quality and the set goals for its improvement, a decision is made to create a new or improve the already established quality management systems, if the level of product quality is relatively high. In addition, the developed goals should completely comply with the accepted strategy of the enterprise and the strategic directions corresponding to it. In accordance with this approach, the main strategic goal of quality management – improving product quality by solving current problems - improving the quality of raw materials, quality of work, enhancing quality control and accounting for defects, upgrading the material and technical base of production, etc. This goal is closely interrelated with the goals of innovative

development and reduction of production costs, as without them it is impossible to achieve maximum quality in the socio-economic aspect, so these tasks must also be considered when designing quality management systems. Thus, this approach will contribute to a fuller integration of the quality management system into the overall management system.

Stage 3 – identification of management functions and business processes through which quality management is carried out. When designing control systems, it is first necessary to identify the functions related to product quality management, and to establish their relationships with production management functions, business processes. The feasibility and efficiency of the tasks set by the system depend on correct identifying the control functions, as the incorrect identification of control functions can lead to incorrect construction of the management system structure. Besides distinguishing quality management functions from the general production management system, it is important to identify business processes related to the quality management system. This step plays an important role in implementing the principle of process and system approaches, according to which an organization should identify the processes necessary to create values, assess their relationships, ensure their management. This stage provides a comprehensive management coverage of all stages of the product life cycle, as well as additional processes and elements that affect product quality.

Stage 4 – designing product quality management systems. Product quality management systems have specific features that distinguish them from other management systems, as quality management systems are created not to perform specific management functions, but to solve a set of tasks related to the implementation of control-analytical, socio-economic, legal and other quality management functions. That is why quality management demands a comprehensive approach covering not only the functions of quality management, but also cross-functional problems related to the quality of technical documentation, planning, material and moral incentives, legal regulation of quality, etc.

Stage 5 – developing organizational and economic mechanism of quality management. In order to implement and ensure the stable functioning of the quality management system, it is necessary to create an operation mechanism of such a system that would be able to implement the requirements of economic laws and patterns of quality development in the practice of product quality management.

Thus, the system of organizational support for quality management in practice can be considered for medium and large companies. The system of organizational support depends on the corporate organizational, economic, technical and human resources. From the point of view of the organization, it is expedient to allocate a structural unit, in the area of responsibility of which are the organizational and economic process and quality management projects. From the standpoint of economic structuring, it introduces centers of responsibility or centers of control-analytical, socio-economic accounting of quality management, called quality centers.

Conclusions. Extensive use of quality management systems, methods, and tools allow identify and structure organizational problems, systematize the company's quality activities and increase their competitiveness. The concept of modeling of organizational and economic mechanism of quality management for the enterprises of this branch and possibilities of its realization within the limits of globalization processes is offered. They make it possible to determine manufacturability, objectively select corrective and preventive actions and identify ways to develop it. The practical significance of the obtained results is determined by the relevance of the tasks and the specific focus on the formation of organizational and methodological mechanism to improve product quality management at domestic engineering enterprises.

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