KAPITEL 4 / *CHAPTER 4* [4]
IMPROVING THE EFFICIENCY OF THE PRODUCT QUALITY MANAGEMENT SYSTEM AT A MANUFACTURING ENTERPRISE

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Introduction.

The concept of product quality and its management has deep historical roots, dating back to the formation of artisanal production. The evolution of quality management systems occurred gradually - from individual control of the master to the formation of integrated corporate systems based on international standards and principles of total quality management (Total Quality Management - TQM). Each historical stage reflected not only the development of technologies, but also a change in management paradigms, economic conditions and consumer requirements.

Pre-artisanal and artisanal stage (until the 19th century). At the initial stages of production development, product quality was determined by the personal skill of the manufacturer. The craftsman independently controlled the entire process - from the selection of materials to the inspection of the finished product. Quality was the result of individual responsibility, and control was carried out directly by the consumer through trust in the name of the master. At this stage, there is no systematicity, but the foundations of personalized responsibility for the final result are laid, which will become one of the principles of modern quality management [1].

The industrial stage and the emergence of technical control (late 19th - early 20th century). With the development of machine production and standardization of processes, the need for specialized forms of control arises. Production becomes mass, and therefore, the personal responsibility of workers decreases. During this period, the concept of technical quality control (Quality Inspection) is born, which is based on the detection of defects after the completion of the production cycle. The first technical control departments (VTK) are created at enterprises, the task of which was to reject low-quality products. The disadvantage of this approach was that quality was

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considered only as a function of control, not management, that is, defects were eliminated post facto, and not prevented at the production stage [2].

4.1 Development and essence of the concept of product quality management

The stage of statistical quality control (1920–1940s). The further development of the quality management system is associated with the works of American scientists W. Shewhart, G. Dodge, G. Romig, who laid the foundations of statistical quality control (Statistical Quality Control – SQC). Shewhart first proposed the use of control charts to monitor the stability of technological processes, which made it possible to prevent the appearance of defects, and not just detect them. This approach became the foundation of systemic control, when quality began to be considered as an object of management, and not a random result. In the 1930–1940s, statistical analysis methods were actively introduced in US industry, in particular in the aviation and military sectors.

Formation of comprehensive quality management systems (1950–1970s). After World War II, Edward Deming, Joseph Juran, and Armand Feigenbaum played a leading role in the development of the theory and practice of quality management. They proposed a fundamentally new understanding of quality as a strategic function of enterprise management.

– Deming developed the PDCA (Plan–Do–Check–Act) cycle, which became the basis for continuous process improvement.

– Juran focused on the role of management and formulated the concept of a "quality chain" that covers all stages – from design to after-sales service.

– Feigenbaum introduced the term "Total Quality Control", by which he understood a quality management system that covers all divisions of the enterprise.

During this period, the active implementation of the Kaizen system, focused on the collective participation of employees in improving processes, began in Japan. The result was the formation of the Japanese quality model, which ensured the success of such companies as Toyota, Sony, and Mitsubishi.

The stage of standardization and international unification of quality systems (1980-1990s). The globalization of markets has necessitated the creation of unified approaches to quality assessment. In 1987, the ISO 9000 series of standards was first adopted, which established international requirements for quality management systems. Their concept is based on a process approach, consumer orientation, management leadership and continuous improvement [3].

4.2 Quality management system as a component of strategic management of an enterprise

At present, the TQM (Total Quality Management) model is actively spreading - comprehensive quality management, combining strategic, organizational and social vision. It involves the integration of quality into all areas of the enterprise's activities: production, marketing, personnel, logistics, communications.

The modern stage - digitalization and sustainable development (2000s - present). At the beginning of the 21st century, quality management goes beyond purely production processes. The concept of an "Integrated Management System" (IMS) is being formed, which combines quality management, environmental safety, occupational health and safety, energy efficiency and social responsibility.

The use of information technologies – ERP, CRM, MES systems – allows you to automate quality control, track defects in real time and predict risks. At the same time, the approaches "Zero Defects", "Lean Production", "Six Sigma", aimed at minimizing losses and achieving stable quality without additional costs, are becoming relevant[4-6].

In the context of sustainable development, quality is considered a key criterion for the environmental and social responsibility of an enterprise, which increases the trust of consumers and partners.Thus, the evolution of quality management systems reflects the transition from result control to process management, and then to a strategic approach that integrates quality into all levels of enterprise management. The modern paradigm of quality management is based on systematicity, personnel participation,

digitalization and consumer orientation.

In today's conditions of global competition and high consumer expectations, quality management has become a comprehensive system of a strategic nature, covering all levels of the enterprise's activities - from product design to customer service. Product quality management in modern conditions is considered as a strategic function of the enterprise, aimed at achieving stable production efficiency, meeting consumer needs and creating competitive advantages. Modern approaches to quality management are based on the integration of international standards, management philosophies and methodologies, among which the key place is occupied by the ISO 9000 systems, the Total Quality Management (TQM) concept, as well as Lean and Six Sigma methods.

The ISO 9000 series standards, in particular ISO 9001, constitute a universal basis for building quality management systems based on process and risk-based approaches. Their application ensures consistency in planning, implementation, control and improvement of production processes in accordance with the PDCA cycle (Plan–Do–Check–Act). The key principles of ISO are customer orientation, management leadership, staff involvement, evidence-based decision-making and continuous improvement. The implementation of these standards helps to increase the trust of partners, reduce production risks and increase the transparency of the enterprise's activities.

The concept of TQM (total quality management) considers quality not as a separate control function, but as a philosophy of organizational development that covers all levels of management. Its basis is the collective participation of employees in improvement processes, customer orientation and the formation of a culture of continuous improvement. Within the framework of TQM, special attention is paid to the human factor - staff motivation, effective communication and management responsibility for the result. Thus, quality is considered as the result of the integration of technical, managerial and social components of the enterprise system [7].

Lean Management methodology focuses on eliminating losses and increasing the value of the product for the consumer. Lean production is based on optimizing value

streams, eliminating redundant operations, defects and downtime, which ensures the rational use of resources. Among the main Lean tools are 5S, Kanban, Kaizen, Just-in-Time - thanks to which the enterprise achieves increased productivity and flexibility without additional costs.

The Six Sigma methodology, in turn, focuses on quantitative measurement of the quality level and reducing variation in processes to a minimum. Using the DMAIC cycle (Define–Measure–Analyze–Improve–Control), it ensures accurate identification of the causes of deviations and the construction of a system for constant monitoring of results. Six Sigma combines statistical analysis and management practice, which allows you to reduce the number of defects, optimize costs and increase customer satisfaction.

Modern quality management practice involves not the separate application of these methods, but their integration within a single management system. The combination of ISO and TQM principles with Lean and Six Sigma technologies forms a management model focused on achieving high efficiency, minimizing losses and ensuring stable product quality. For manufacturing enterprises, in particular, LLC "KAPAROL DNIPRO", this approach is of particular importance, as it allows maintaining competitiveness, optimizing processes and ensuring compliance of products with international quality requirements.

One of the notable achievements in the field of theory and practice of quality management is the Noriaki Kano model, which has become widely used as an analytical tool in the management of consumer value of products. It is based on determining the relationship between the degree of implementation of functional characteristics (attributes) of a product or service and the level of consumer satisfaction. The essence of the model lies in the ability to classify product properties according to their impact on the perception of quality, to identify characteristics that form customer loyalty, and to direct the company's efforts to create products that are most attractive to the market[8].

The Kano model involves the identification of six main groups of requirements for a product or service: basic, desirable, exciting, doubtful, reverse and unimportant

factors.

Basic factors determine the minimum level of consumer expectations - their absence causes dissatisfaction, but their presence does not increase positive perception. They are perceived by the consumer as mandatory quality conditions. Desirable factors have a proportional relationship between the level of their implementation and customer satisfaction: the higher the level of function performance, the greater the satisfaction. It is these attributes that form the competitive advantages of the enterprise. Exciting factors are characteristics that exceed customer expectations, creating the effect of a pleasant surprise. Their absence does not cause dissatisfaction, but their presence significantly increases consumer loyalty.

Reverse properties are characterized by a negative impact on the perception of quality - they cause irritation or complicate the use of the product. Such elements need to be eliminated from the design or service process. Unimportant factors do not have a noticeable impact on the level of satisfaction, so their maintenance is economically inexpedient. It is advisable for the manufacturer to identify such characteristics in order to avoid unnecessary costs. Questionable factors are uncertain - the reaction of consumers to them is inconsistent or depends on the context of use, so they should be studied empirically.

Practical application of the Kano model allows enterprises to effectively structure consumer expectations and determine which properties of the product ensure its market attractiveness. The method is actively used not only in industrial production, but also in the service sector - tourism, transport, hotel business, education, etc. Its advantage is its dynamic nature: product attributes change their significance over time, so the model requires periodic updating and re-application.

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The essence of the method is a structured analysis of potential failures, their causes and consequences with the subsequent development of measures aimed at preventing or reducing the likelihood of their occurrence. Its application is appropriate in the process of designing new products, modernizing existing products or improving technological processes. Thus, FMEA analysis acts as a tool for managing quality risks in the early stages of the product life cycle.

The objects of FMEA can be individual products, systems, production processes, software or service elements. The method is based on several methodological principles: teamwork, hierarchy, iterativity and documentation of results. The team approach involves the participation of representatives of different departments in the study - marketers, engineers, technologists, quality managers - which ensures the

comprehensiveness of the assessment. Hierarchy means the analysis of potential failures both at the level of individual components and from the point of view of the impact on the system as a whole. Iterativity reflects the repeatability of the analysis process in the event of changes in product characteristics or requirements, and documentation ensures that all results are recorded and used to improve processes.

A typical FMEA algorithm includes defining the object of study, identifying its elements, identifying potential defects, establishing the causes and possible consequences of their occurrence, and calculating the risk index (Risk Priority Number – RPN). The assessment is carried out according to three criteria: the probability of a defect, the severity of its consequences, and the probability of detection, after which the priority of corrective actions is determined. Thus, FMEA allows the company to focus resources on eliminating the most critical risks.

Important quality management tools also include the methods of optimizing product design by Japanese researcher Genichi Taguchi, which combine engineering and statistical approaches. Their main idea is to increase the stability (robustness) of product or process parameters by reducing variability, which directly affects the level of quality and consumer satisfaction. Taguti emphasized that quality is formed at the design stage, when changes are least costly, and therefore its management should be preventive, not corrective.

Taguti's methodology is based on the use of experimental design and a loss function, which quantitatively expresses the relationship between the deviation of product parameters from nominal values and the amount of economic losses of the enterprise. Accordingly, the greater the variability of the process, the greater the costs of quality assurance. Reducing the spread of parameters allows you to reduce the risk of failures, stabilize processes and at the same time optimize costs.

Thus, both FMEA analysis and Taguti methods implement a common concept of preventive quality management, focused on process stability, eliminating the causes of defects and achieving a sustainable balance between product quality and production costs. Their application within the framework of a modern quality management system provides enterprises with the opportunity to predict risks, reduce the number of non-

conformities and increase consumer confidence in products.

The Six Sigma methodology occupies a leading place among modern quality management tools and improving the efficiency of business processes. It is defined as a systematic approach to maintaining stable quality of products and processes by reducing their variability, minimizing defects and preventing errors in creating consumer value. The main idea is to strive to achieve a quality level at which the number of defects does not exceed 3.4 cases per million opportunities, which corresponds to the sixth sigma level in the statistical distribution model [10].

The Six Sigma methodology is not only a control technique, but also a management philosophy aimed at data-based decision-making, systematic process improvement and customer orientation. Its task is to focus on indicators that are critical to customers (Critical to Quality), to form a single basis for measuring process performance based on statistical criteria and to create conditions for continuous quality improvement.

The Six Sigma concept is based on a number of basic principles of process management: process orientation, recognition of natural variability, differentiation of general and specific causes of deviations, understanding the difference between stable and unstable processes, as well as awareness of the need for continuous improvement. The key thesis is the recognition that any process has internal variability, which can be measured, analyzed and reduced using statistical methods. It is the control of variability that acts as the central mechanism for achieving high quality.

Conclusion.

The practical implementation of the methodology is carried out through the DMAIC cycle (Define – Measure – Analyze – Improve – Control), which is iterative in nature. At the Define stage, problem processes are identified, goals and customer expectations are formulated. During the Measure stage, data on process characteristics is collected, variation analysis is performed, and potential risk areas are identified. The Analyze stage focuses on identifying the causes of defects and statistically testing hypotheses regarding influencing factors. In the Improve phase, measures are

developed and implemented to eliminate or minimize the impact of these factors. The final Control stage involves verifying the achieved results, stabilizing the updated process, and creating a monitoring system to maintain the achieved quality level. An important feature of Six Sigma is the combination of managerial and analytical approaches. It involves involving personnel at different levels – from workers to top management – through a training and certification system (White Belt, Green Belt, Black Belt). This approach forms a corporate culture of continuous improvement, where each employee is aware of their role in ensuring the stability of processes.

Thus, the Six Sigma methodology is a powerful tool for reducing process variability, increasing the effectiveness and efficiency of the enterprise. It helps to achieve a balance between quality, costs and consumer satisfaction, forming the basis for sustainable development and strengthening the competitive position of the organization in the market.

In the process of developing quality management systems, a wide range of methods and approaches has been formed aimed at increasing the efficiency of production processes, reducing the variability of results, preventing defects and maximally satisfying consumer needs. Each of these methods has its own conceptual basis, scope, advantages and certain limitations, which necessitates their critical comparison. Generalization of the main characteristics allows us to systematically assess the potential of each of the approaches in the context of building a comprehensive quality management system at the enterprise.

In order to present the results of the theoretical analysis in a structured way, which reflects the essence, purpose, advantages and disadvantages of the most well-known quality management methods used in modern management practice. In our opinion, the disadvantages of the considered methods do not reduce their practical significance, since each of them focuses the attention of the enterprise management and personnel on the main thing - continuous improvement of the quality of products and processes, increased productivity and efficiency of activities based on consumer orientation.