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Directions of Development of the Quality Management System of Industrial Enterprises

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Abstract: In order for the quality management system to work effectively, it is necessary to study the stages of quality management systems development and modern trends. In this article are described the main stages of the evolution of the quality management system of industrial enterprises and the current directions of development. In the course of the study, a comparative analysis of foreign literature was carried out.

Key words: *quality, evolution of Quality Management System, product quality improvement, digitized Quality Management System, competition, digital economy, digital transformation*

In the activities of the enterprise and organization, it is important to analyze the stages of the evolution of scientific thought and practical work on the development of the quality management system in order to understand the role and importance of quality management. Quality management system (QMS) is an integral part of the overall management system of the enterprise, which should ensure the stability of the quality of products or services, as well as help to increase customer satisfaction. According to the SMT methodology, it is a business process system built on a process management model aimed at managing the quality of a product or service. Quality management as an independent field of scientific and practical activity began to take shape at the beginning of the 20th century. In modern theory and practice of Quality Management, the following stages of evolution of this field are distinguished. Modern scientific approaches to Quality Management date back to 1905 [1].

The first phase begins with the era when the first steps of a systematic approach to management were taken, the YA'ni being a link with the emergence of Frederick Taylor's system. According to the rules of this system, it was necessary to set technical and production standards by specialists and engineers, while workers were obliged to comply only with them.

This system established requirements for the quality of products (parts) in the range of quality field limits, and provided specific templates that defined error limits that could be high and roadbed. To ensure the successful operation of the Taylor system, the first quality specialists - inspectors were introduced. The incentive system includes fines for defects and poaching, as well as dismissal. The training system included vocational training and training to work with measuring - control equipment. Relations with suppliers and consumers are built on the requirements set out in the technical conditions (TSh), the fulfillment of which is checked during admission control (entry and exit).

The mentioned characteristics of the Taylor system made it a quality management system for each individual product (part). But the product is the result of the implementation of production processes, so it has been suggested that the whole process should be managed.

Second stage. In 1924, "Bell Telephone Laboratories" (Now AT&T Corporation) acquired R.L.A group was formed under Jones, and he laid the foundation for statistical management of quality. In It V.Control cards developed by shukhart, G. Dodge and G.Sampling sample tables of quality control developed by Rooming were used. Basics of statistical quality management later E. As a result of Deming's activities, it became very widespread in Japan, which had a huge impact on the country's economic revolution. Deming puts forward the idea of canceling the execution of the task and the assessment of its result, because, in his opinion, they create an atmosphere of fear, make short-term contributions to work, ignore long-term tasks and disrupt teamwork. E. Relying on Deming's point of view, D. Juran introduced the term quality to the use of the term "consumer compliance", to which quality must be primarily focused on consumer requirements (suitability for use).

Stage three. In the 1950s, the concept of TQC (Total Quality Control) – general quality control was put forward. Its author, the American scientist A. Feygenbaum, who published his paper" complex Quality Management " in 1957. The main tasks of the tqc include predictably eliminating possible inconsistencies of products at the stage of design development, monitoring the quality of raw materials, products, components and materials supplied, as well as production management, service development and monitoring compliance with established quality requirements. Feigenbaum called for a focus on studying the causes of inconsistencies, as well as being the first to emphasize the importance of a cost accounting system for quality [2].

In Japan, the ideas of TQC were enthusiastically received and considered quality - a management task, professor K.Ishikawa's work was further developed. Isikawa called for the participation of all employees in quality improvement measures and introduced the term "consumer-supplier relations". Unlike American concepts, he spoke of" quality control at the company level "("Company Wide Quality Control").

TQC systems have developed in Japan with great emphasis on the use of statistical methods and the involvement of employees in quality circles. The Japanese claimed to use the TQSC approach, where “s” denotes statistics.

Philip B. Crosby (Germany) is one of the most famous proponents of the tqc concept. In the early 60s of the 20th century, he detailed the program "Zero Defects", which caused heated controversy in Germany. Crosby focused on the tasks in the field of Enterprise Management, proposed the introduction of an entrepreneurial culture, which called for the realization of the value of quality [1].

Of course, in different countries of the world, the introduction and development of the tqc concept was carried out unevenly. Although all the main ideas of the tqc were developed in the United States and Europe, Japan has become a clear leader in this area. As a result, Americans and Europeans were forced to learn from the Japanese, but this study was enriched with innovations.

In European countries, great attention began to be paid to the documentation of quality assurance systems and their registration or certification by a third (independent) person. Systems of relations between suppliers and buyers also begin to provide third-party certification of products. At the same time, the requirements for the quality of raw materials in contracts became more serious, and their guarantees of fulfillment began to become more responsible.

It should be noted that the stage of development of systemic, Integrated Quality Management was not overtaken by the Soviet Union - many domestic systems had appeared. Among them: the Saratov system for the production of products without defects (BIP); the scientific organization for work on the reproduction of engine resources created in the Yaroslavl Association "Avtodizel" (NORM); the

Rybinsk scientific organization for Labor, production and management (NOTPU), developed at the Rybinsk motor production plant; "from the first products - the Gorky system" quality, reliability, resource " (CANARSPI).

Stage 4. In the 80s, the transition from general quality control (TQC) to general quality management (TQM) began. At this time, new international standards for quality systems appeared - the ISO 9000 (1987) standards, which had a huge impact on management and quality assurance. In 1994, a new version of these standards was released, which primarily expanded the MC 9004-1, -2, -3, -4 standards, with more emphasis on quality assurance issues of software products, recycled materials, and services.

The peculiarity of General Quality Management (TQM)is that if earlier decisions were made at enterprises based on a compromise on parameters such as product size, delivery time, costs and quality, now the quality of the product - is put first, and the work of the enterprise has become obliged to obey this goal.

If TQC is a quality management to fulfill the specified requirements, TQM is also the organization's goals as well as requirements management. TQM also includes a quality guarantee that is interpreted as a system of measures that reassures the consumer of the quality of the product [8].

The TQM system is a comprehensive system aimed at constantly improving quality, minimizing production costs and timely delivery. The main ideology of the TQM is based on the principle “there is no limit to improvement.” When it comes to quality, the goal is zero defect, zero additional costs and the desire to deliver on time. At the same time, it is understood that it is impossible to achieve boundaries, but it is necessary to constantly strive for this, without stopping at the results achieved. The TQM system employs quality management techniques to suit the objectives. One of the main features of the system is the use of collective forms and methods of searching, analyzing and solving problems, constant participation in improving the quality of the entire team.

Fifth stage. In the 90s, the influence of society on enterprises increased, enterprises began to take into account the interests of society more and more. This led to the emergence of the ISO 14000 series of standards that define the requirements for management systems in terms of Environmental Protection and Product Safety [10].

The influence of the humanistic component of quality increased significantly, and the attention of the heads of the enterprise to the satisfaction of the needs of its employees began to increase.

Corporate quality management systems are also emerging, aimed at strengthening the requirements of international standards and taking into account the peculiarities of such corporations. Thus, The Big Three American automobile companies developed the QS 9000 "requirements for a Quality System" standard in 1990 (1994-second edition). Although it is based on the ISO 9001 standard, its requirements are strengthened by the individual requirements of the industry (automotive), as well as the "Big Three" and five other large truck manufacturers [7].

The ISO 14000 and QS 9000 standards, as well as the introduction of self-assessment methods based on Quality Award models, are the main achievement of the fifth stage of the development of the quality management system.

Taking into account the state standards attached to the quality management system, it is currently possible to indicate the following as directions of digitization of QMS [4]:

1. Digitization of the design of processes for the production of products and services:

- Electronic drawings;
- Electronic 3D model;
- Electronic model with production data (design and technological data);
- Electronic model and electronic structure delivered to all parts of the enterprise;
- An electronic model that can be used for different purposes is the “digital twin”.

2. Digitization of production:

- create original ecosystems of digital platforms, advanced digital technologies. Predictive analysis and a large data-driven approach make it possible to combine geographically distributed participants in design and production processes, to increase the level of flexibility and customization;
- to develop a system of digital models of newly designed and manufactured products and production processes, in which the models have a high level of adequacy to real objects and real processes (convergence of the material and digital world, causing synergistic effects;
- digitization of the entire life cycle of products (from preliminary design to disposal). The more timely adjustments are made, the lower the cost of the product, so the design processes will be of priority. At the stage of the formation of digital production, new basic competencies are formed:
- the use of systematic engineering when it is necessary to constantly take into account the system, as well as its individual elements;
- the formation of a matrix of multi-level goals and limitations as the basis of the new design, which significantly reduces the risks, the volume of tests and the volume of work associated with the improvement of products based on tests;
- change management throughout the entire life of the product;
- digital certification based on thousands of virtual tests of individual components and the entire system as a whole [6].

1. Digitization of the Metrological supply of SMT.

- The goal is to develop methods for processing and analyzing large amounts of data [5].
- Metrology of communicative systems for digitization. In complex scenarios, reliable, safe and effective communication maintenance and metrological validation are considered. This includes monitoring complex high-frequency measurements for 5G networks, non-linear and high-frequency statistical data, measurements taken in digital communication networks, and complex antenna systems.
- Metrology for modeling and virtual measuring instruments. Automated production management for automatic evaluation of measurement results by developing analytical methods and validation procedures for networked and virtualized measurement systems, and simulation of measurement systems for the purpose of planning and analyzing experiments, methods and standards for virtual measurement processes are actively supported (e.g. optical shape measurement technology or coordinate measurement technology).

Digitization of analysis activities in QMS.

- Data registration and analysis. This is one of the most complex and complex tasks in QMS. The emergence of high-speed data storage and processing systems makes it possible to solve the problem of measuring and recording all types and, most importantly, necessary information that affect (or may affect) product quality more efficiently than before. The use of the Internet of Things (Internet of Things) to measure the performance of processes, as well as products, is a prerequisite for the formation of large data sources. The use of sensors installed on current products ensures that the manufacturer transfers information about operating conditions, performance, failures, etc.throughout the life of the product. This makes it possible to continuously improve products, anticipate and prevent failures in its operation, and reduce maintenance costs. At the same time, Big Data is able to analyze these arrays of data coming from different sources. The main sources of information can be: customers, suppliers (contractors), competitors, other enterprises, partners, regulatory bodies - external sources; products, processes, materials, raw materials, personnel, work environment and infrastructure are internal sources of Information [9].
- Monitoring and monitoring of QMS processes. A statistical data processing method (statistical methods) is often used to control processes in a quality management system. With the advent of

algorithm studies for neural networks, artificial intelligence has become possible for these purposes. A trained neural network allows you to identify trends (trends) and changes in processes much more efficiently and faster than a person or automated systems based on statistical data processing.

- Development and design verification and validation. (Verification is the provision of affirmative evidence that a given object meets the specified requirements. Validation is the verification that the specified requirements are related to the intended use). Many processes of the organization's activities must confirm the objectivity of the evidence obtained regarding compliance with the established requirements. Blokcheyn technology provides a system of proof of compliance with safe, decentralized and fully objective requirements and allows you to monitor the product throughout the entire creation chain. Under such a system, the creation of forged certificates or their replacement is excluded. It is also possible to obtain important information about suppliers, customers, partners, competitors, government bodies and other stakeholders. Information about important actions of all stakeholders can be stored on the basis of distributed registers using this technology [10].

- Decision-making based on data (evidence) in conditions of uncertainty (uncertainty). State standards of quality management systems require the creation of sufficiently strict algorithmic processes for the execution of procedures. If the process is complex and branched, the execution of operations depends on changes in parameters, then it is necessary to regulate all types of processes, or rely on the decision of qualified experts for the progress of the process. Any uncertainty can lead to an undesirable situation in the process. The integration of modern digital technologies makes it possible to solve this problem through the use of predictive (predictive) analysis. Thanks to predictive analysis tools, companies can analyze and predict processes that occur over time, identify trends, anticipate changes, and therefore plan the future more efficiently [11].

Conclusion. Summing up, we can say that now it is necessary to apply the Basic Rules of the concept of TQM, which reflect one of the most important trends in the development of Quality Management - the most modern views and approaches.

Summarizing all of the above points, it should be noted that:

- quality management is not a narrow specific activity bounded by organizational circles, but a management activity of the entire enterprise, all aspects of its life in a global sense, necessary for its viability, with a clear focus on the needs of the consumer;
- the main factor in quality assurance is employees working in the organization; the main task of the leader is to activate the potential abilities of employees by providing effective incentives and an educational system;
– it is necessary to have an effective information exchange system in the conditions of digitization of the economy;
- the basis of quality management is to eliminate not the defects themselves, but their underlying causes; although it is more laborious, it gives effective results;
- freedom is necessary when choosing the tools and methods that provide the basis for teamwork.

To increase the effectiveness of the organization, it is necessary to create a special cultural environment in it and bring in modern trends in quality management.

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