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QUALITY MANAGEMENT – THE BASIS FOR SUCCESSFUL ORGANIZATIONAL MANAGEMENT

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Abstract

In modern economic conditions, quality is a motivating factor for the growth of companies in the conditions of the dynamism of the market environment. The requirements for the quality of products and services are constantly increasing. Consumer expectations, the desire to achieve company goals, increased competition and regulatory requirements determine the development of the concept of quality and its management in all spheres. As a result, new management methods and concepts are being developed and implemented, from production control through quality assurance, development of standards and transition to its total management.

Keywords: Quality, Management, Organizational Management, Personnel, Standard, ISO

INTRODUCTION: The Problem of Quality and Its Management and The Need For Tools

The historical concept formed with the development of Taylorism and the creation of mass production at Ford has focused on the final control to guarantee quality, through its control at the end of the production process. Today, the concept of quality has changed to the fact that it is planned, created, ensured and controlled from the production of the product to the provision of the service. The instruments of quality planning, the introduction of preventive measures to eliminate or reduce errors, reduce costs and achieve greater efficiency come to the fore.

What are the relevant challenges that affect the concept of quality?

What are the methodological approaches?

How do managers' views change when quality is the goal of the organization?

Interest in quality is constantly growing in theoretical and practical terms. Quality management occupies a significant share in the subject of various sciences, is actively present in the object of modern theoretical and empirical interdisciplinary research.

The various aspects of the modern view of quality require consideration taking into account the development of the macro, micro and internal environment of organizations.On this basis, a need arises for knowledge of tools, as well as didactic and methodological knowledge for their dissemination and use in theory and practice.

QUALITY CHARACTERISTICS AND INDICATORS

The complexity of quality is related to the measurability of its characteristics, which can be qualitative or quantitative. This is not only a methodological problem in science, but also a significant problem of practice in the field of corporate quality management. Every enterprise that wants to implement effective quality control must decide how to carry out quality assessment.

A quality characteristic, according to clause 3.6.2 of EN ISO 9000:2015 “is a distinctive property inherent in a product, process or system, related to a requirement” [45]. An inherent characteristic is one that is permanent, actually existing, and not supplemented (for example, as a product price, product owner, etc.).

There are different types of characteristics, according to Note 3 to Clause 3.5 of EN ISO 9000:2015, such as:

- Physical (e.g. mechanical, chemical, electrical or biological characteristics);
- Sensory (e.g. smell, taste, vision);
- Time-related (e.g. accuracy, reliability, etc.)
- Behavioral (e.g.: politeness, etc.).

Characteristics can be objectively measurable or subjectively perceived by the customer, as follows:

- Objective measurability refers to features that are measurable by methods independent of the observer, using modern achievements of the natural sciences, mathematics, statistics, etc.;
- Subjective measurability faces the problems of expectations, validity and reliability presented by the user.

The specific requirements for the characteristics that enable their implementation and verification are called quality indicators.

The theoretical and practical problems of quality assessment (product, services, processes and systems) are the subject of the science of qualimetry. It deals with the development of indicators and unified methods for quality assessment.

There are groups of “established” quality indicators [Demirova, S. Technical Development and Industrial Logistics, Journal of Innovations in Discrete Manufacturing, Sofia, issue 1/2016], which can be systematized depending on:

 Product properties:

– functionality, related to the degree to which the product meets the goals of its intended use;

– ergonomic indicators, such as the degree of adaptation of products to the anthropogenic, psychophysical and psychological characteristics of the human organism in the “product-man-environment” relationship;

– reliability, such as suitability for performance and influencing factors, such as reliability, repairability and maintenance;

– manufacturability, such as: labor-intensiveness, material-intensiveness, etc.;

– safety, such as: frequency of incidents, manifestation of occupational diseases, workload, etc.;

– environmental friendliness and impact of the product’s life cycle on the environment;

– aesthetic, such as design (shape and color), etc.;

– economic indicators;

– patent-legal indicators in compliance with certain regulatory requirements, for example, marking, etc.

 The number of characteristics to which they apply:

– a single indicator that refers to one characteristic, or

– a complex indicator for several characteristics.

 Stage of application:

– design indicators;

– production indicators;

– operational indicators;

– forecast indicators.

 Their importance for quality assessment:

– basic indicators and

– additional indicators.

The last chapter also shows economic indicators that can be used in this direction. The system of indicators makes it possible to assess quality and manage it at all stages of the product or service life cycle.

QUALITY AND POLICY OF THE ORGANIZATION

The effectiveness of management depends to a large extent on the culture of the organization and requires the integration of each employee at his workplace into quality issues.

This requires that staff become aware of the real importance of achieving quality. According to William Edwards Deming [Deming, B.E.,K.Ed.Gahill The New Economics for Industry, Government, Education, MIT Press, 2015.], this develops in the following directions:

- every activity inside and outside the organization can be viewed as a process and thus be continuously improved;
- it is not enough to solve quality-related problems, changes need to be made;
- management must serve as an example in quality activities.

As a result, at every moment and stage of the processes in the organization, product quality can be achieved in the chain: consumer-supplier.

The quality of the product, or service, is the result of all activities at all stages of the life cycle. Quality management is not only related to improving market positions, but also to increasing financial results. The model is known as the Deming quality chain.

At the beginning and end of the Deming quality chain stands the person who, through his efforts to improve the quality of products and processes, leads to improved productivity in the organization. Reducing costs determines competitive prices on the market and a stable market share.

Ensuring market share is related to preserving jobs and motivating staff. The W.E. Deming chain, deployed on a global scale, becomes a factor for continuous quality improvement.

Understanding the essence of quality, knowledge of its philosophy, strategies, techniques and methods must be gradually applied in all areas of the organization, which requires the creation of a corporate culture of quality.

FUNCTIONS OF QUALITY MANAGEMENT

Quality management, as a set of all quality activities, according to the German Quality Organization (DQS), has the following functions: quality planning, management, control, quality improvement, quality performance and quality audit.

The tasks of quality planning are related to the selection, classification and ranking of quality characteristics, as well as specifying the technical requirements of quality. Quality planning is important because the later a defect appears, the greater the costs associated with its removal.

Quality management is related to monitoring, coordination in order to meet quality requirements. Quality control assesses compliance with quality requirements. This is done by checking the set and actually measured parameters. Quality improvement is understood as all measures related to increasing the effectiveness and efficiency of activities and processes. The

quality approach describes all planned and systematic activities and is implemented through a quality management system. A quality audit is a systematic and independent study to determine whether the results obtained correspond to the planned requirements and whether they meet the objectives of the quality policy. The systematic implementation of quality management functions is a prerequisite for the success of the organization.

METHODS FOR PRODUCT QUALITY ASSURANCE

General Provisions

A number of methods, techniques and approaches, the so-called quality toolbox, play an important role in ensuring and improving quality. There are different classifications of instruments, depending on their application in:

- the stages of the Deming Cycle (PDCA);
- the stages of the life cycle of products or services (pre-production, production, non-production);
- when affecting objects;
- according to the type and number of parameters studied;
- according to the level of complexity;
- according to the algorithm of action of the instruments, etc.;

In the proposed classification, the criteria used for the instruments in separate groups depend on their appearance and their content. In the theory of quality management, their systematization according to the Deming Cycle is generally accepted

In this regard, the preventive nature of methods and techniques is of particular importance. According to a number of studies, for example by the Institute for Quality Management in Stuttgart, the highest share (70%) of non-conformities occur at the product planning stage and the highest share of non-conformities elimination (80%) is at the production and distribution stages.

On this basis, the identification, analysis and resolution of problems at the planning stage would reduce errors at the final control, distribution or even customer stages. This requires that “it is better to prevent errors in advance than to correct them” [Linß , G. Qualitätsmanagement für Ingenieure, Carl Hanser Verlag GmbH & Co. KG, 4 Auflage, 2018]. Non-conformities that appear at the production or operation stage lead to high costs for correcting defects, the occurrence of defects, customer complaints and a bad image of the organization.

According to item 2.7.3 of BDS EN ISO 9000:2015 “Quality management systems. Fundamentals and vocabulary”, the appearance of a defect, such as failure to meet a

requirement regarding intended or specified use ... “has a legal nature, in particular, related to the manufacturer’s responsibility for the product”. Thus, the targeted application of methods and techniques for quality assurance contributes not only to improving quality, but also to optimizing production costs.

Depending on their application, the methods are divided into preliminary, preventive, pre-production and operational, production. Methods and tools for finding/implementing solutions also play a major role: problem-solving plans, creativity techniques, brainstorming/writing, mind mapping, affinity diagrams, ABC analysis, portfolio diagrams, action lists, Gantt charts, etc. The following presentation will examine some of the known methods and techniques for ensuring product quality.

QUALITY ASSURANCE METHODS

Quality Function Deployment (QFD)

In the product planning phase, the method “Quality Function Deployment” (QFD) is most widely used. It serves to transform the product idea into a real product, taking into account its quality aspects and customer requirements. The idea of the method was first proposed by Prof. K. Oshiumi in Japan. In the 1970s, his follower Prof. Y. Akao developed the idea. He applied it practically at the Mitsubishi Kobe shipyard.

In 1574, the method began to be applied at Toyota factories in a project to develop a new car model. The reduction in production costs and development time gave grounds for using the method in other projects. At the same time, the Japanese Society for Quality Control (JSQC) established a Research Committee (Computer Research Committee), headed by Prof. Y. Akao, to apply the QFD methodology.

The objectives of the QFD method are: adapting the technical specifications of the product and planning its quality according to the requirements of users;

- improving communications between different departments and hierarchical levels of the organization;
- improving the visibility of quality planning results;
- identifying critical product quality indicators;
- reducing production costs by eliminating unimportant additional changes in the production phase;
- limiting the development of products that would not have market success.

For the successful implementation of the QFD method, it is necessary to create work teams that include specialists such as: marketers, technologists, designers, and a quality manager.

The individual stages for the QFD method are:

1. Project concept, covering: converting specific user requirements into technical characteristics with appropriate dimensions;

2. Detailed design, which is the conversion of technical characteristics into specific details and product components;

3. Design of technological processes to translate technical characteristics into characteristics of the technological process;

4. Planning of production methods as a combination of technological and production characteristics.

Method For Analysis Of Defects And Their Impact On Quality (FMEA)

The method “Analysis of defects and their impact on quality” (Failure Mode and Effect Analysis – FMEA) is a well-known method for investigating and eliminating potential non-conformities. It is based on assessing the risk of defects, identifying their causes and proposing solutions for preventive actions. It should be noted that there are many authors who have focused their efforts on the study of risk analysis and assessment. There are various definitions of the concept. Some authors define it as the analysis and measurement of values in the threat-vulnerability relationship, while others define it as the most important part of risk management, as a process. [Georgiev, G. Interaction of the Ministry of Internal Affairs with the National Security Service, Academy of the Ministry of Internal Affairs, 2024, ISBN 978-954-348-245-0, p. 105; Ferdov, S., Analysis and risk assessment in the control of the state border of the Republic of Bulgaria, AMVR, Sofia, 2012, p. 35. Babiak, S., Butters, J.& Doll. M.W. 2005, Practical security for management. New Jersey; Paul, B. 2000. Risk assessment. Network. Computing (121-125); quote from: Hanifa, Abdullah. A risk analysis and risk management methodology for mitigating wirless local area networks intrusion security risks. Internet. Pretoria, 2006.] This means that the risks associated with the development and production of a product can be assessed at the planning stage – and the costs arising from product defects and liability obligations can be avoided. In some sectors, such as the automotive industry, customers even prescribe this method to their suppliers. It was developed in the early 1960s for quality assurance in the APOLLO project of the American organization NASA. In the late 1970s, it began to be applied in FORD Motors plants. In the early 1980s, it served as the basis for the development of a series of FORD company standards. Currently, the FMEA method is standardized in some countries. The main objectives of the FMEA method are:

- identification of critical elements of products and processes;
- risk assessment;

 ranking and prioritizing of activities related to error correction;
 improvement of systems, products and processes;
 reduction of changes in series;
 increasing the security of functions and reliability of products;
 reduction of warranty costs and costs for corrective actions;
 reduction of production costs, etc.

FMEA is applied to:

 development of new products, components, systems and processes;
 new areas of application of existing products;
 assessment of safety, security and other important quality characteristics issues;
 introduction of new production methods, etc.

Interdisciplinary teams, including representatives from all functional units involved in the planning, development and implementation of the product, processes and systems, participate in the implementation of the method.

Error Tree Method

The essence of the Error Tree method consists in investigating the causes of unwanted non-conformity. On this basis, a tree structure is built that systematically investigates the causes of these non-conformities. In contrast to the FMEA method, many solutions can be generated with this method. The error tree assessment provides both qualitative and quantitative information for quality assurance. The method is applied in the following sequence:

 preparatory stage of non-conformity assessment, as this stage can be supplemented with a risk analysis.
 development of an error tree. It is recommended to use teams with experts from different functional areas of the organization when applying the method.

Design Review Based On Failure Mode (DRBFM)

The Design Review Based on Failure Mode method is applied in the product development and origination phase. This method was first developed and applied in Toyota plants and its suppliers and has found its place through its efficiency and effectiveness. The Design Review Based on Failure Mode method is a further development of the FMEA method. Experts critically evaluate all changes and the risks and difficulties associated with them. The results obtained through DRBFM analysis can be reused in FMEA and thus reduce the risk in ensuring the quality of products/processes.

The considered methods are used for planning and quality assurance in:

- development of new products, components, systems and processes;
- new areas of application of existing products;
- assessment of safety, security and other important quality characteristics issues;
- introduction of new production methods, etc.

The DRBFM method - Design Review Based on Failure Modes - is becoming increasingly established in quality management as a pragmatic and powerful alternative to the classic FMEA for product changes.

Balanced Scorecard (BSC)

The Balanced Scorecard (BSC) is a multidimensional, dynamic system of indicators that contains both quantitative and qualitative indicators and was first developed in the 1990s by D.P. Norton and R.S. Kaplan. This method looks at the situation in the company from different angles (points of view), using as few key indicators as possible. By default, these are:

- Financial perspective (comprehensive): What are the financial goals of the company? The values of the key figure represent both the result and the basis of entrepreneurial activity.
- Customer perspective: How should the company present itself to the market? Which customers with what requirements should be served in order to achieve the financial goals?
- Process perspective: Which (core) processes are important in order to meet the customers' requirements and achieve the financial goals?
- Employee perspective and potential: Which employee qualifications and skills are important in order to manage the core processes?

The main stages in creating the balance scorecard are:

- Formulation of personal goals and values, especially in smaller and owner-managed companies
- Formulation of the vision (what do we want to achieve by when?) and the mission (how do we want to be seen by third parties? Modern industrialized societies have adopted success as a value. A business that is perceived by others as successful is the mission of every company. [Bozhanova, D. Mental reactions in situations of danger and increased tension, 35 years of the Institute of Psychology, Ministry of Interior, 2007, p. 94-101]
- Definition of strategic corporate goals according to the SMART principle (specific, measurable, achievable, realistic, time-bound)
- Derivation of a corporate strategy: a "battle plan" for target implementation
- Determination of critical success factors (KEF): Which factors are particularly important for the successful implementation of the goals in each perspective?

 Definition of appropriate key performance indicators (KPI): Key performance indicators should be able to realistically represent the respective degree of goal achievement.

 Analysis of the current situation: What is the current state of the company?

 Definition of target values: Target values determine the scope and objectives for implementation.

 Definition of operational measures: Appropriate measures are derived from an initial target/actual analysis, which makes it possible to save resources and systematically implement the objectives.

 Performing target/actual analysis: Subsequent target/actual analyses show the appropriate degree of achievement of the objective.

 Specifying additional or other measures.

STATISTICAL CONTROL METHODS (SPC)

Basics

Statistical Process Control (SPC) methods are used to monitor, analyze and regulate processes. They are a prerequisite for timely detection of the causes of deterioration in the quality of products and processes, reduction of scrap, maintenance and improvement of quality, implementation of the “zero errors” concept, minimization of control costs and losses, etc. A number of factors influence the course of each process. These factors are:

 random;

 systemic.

Random factors lead to deviation of individual values from the average value. The influence of random factors on quality cannot be eliminated.

Systemic factors are known and can be described by functional dependencies [Garvin, D.A., Competing on the eight dimensions of quality, Harvard Business Review, Nov./Dec., 1587]. Processes are considered controllable if the systematic factors that make up its error are removed and the dispersion of random factors is within the intended or desired tolerance range.

Process stability (accuracy) is understood as the set of process properties that are maintained over time under the influence of man, machine, material, method and the relevant working environment. In order for statistical process control to be effective, it is necessary for it to be stable and controllable. The capabilities of the process are represented by an index that connects the actual dispersion zone of the process parameter with the permissible one provided for in the specifications.

A product is considered to be suitable depending on the dispersion of the values of the parameter being checked and their location (the center of grouping) relative to the specified

tolerance limits of the controlled parameter between the upper limit Tg (Upper Control Level – UCL) and the lower limit Tg (Lower Control Level – LCL).

The process capability index Cp is estimated as the ratio between the tolerance T and the dispersion zone V :

Cp = T/V = (Tp – Tr)/V (2.2)

where:

T – tolerance of the controlled parameter;

V – dispersion zone;

Tp – upper limit;

Tr – lower limit.

The study of process capabilities determines the stability of production processes. The following process capabilities are distinguished:

- short-term capability (machine capability);
- long-term capability of the process.

The study of the short-term capability of the machine takes into account the influence of only the machine and technological equipment. The influence of the worker, materials, working environment, etc. are considered constant. For a short period of time, only the condition of the machines has an influence. The main indices are Cm (Machine Capacity Index) and the Critical Machine Index Cmκ (Critical Machine Index).

The study of the long-term capability of the process takes into account its stability in real conditions. Some factors can have an influence, such as: wear of the cutting tool, materials, environmental parameters. In the long-term analysis of process capabilities, opportunities for its improvement can be identified. The main indices are Cp (Process Capacity Index) and the Critical Process Index Cmκ (Critical Process Index). On this basis, recommended index values are developed.

CONTROL CHART

A basic tool for continuous assessment of the state of the process for the purpose of its regulation are control charts. In this type of statistical control, samples are taken from the products under control at a certain interval of time and analyzed using control charts.

A control chart is a graphic method for assessment and statistical control for regulating the course of the technological process. It allows for the detection of deviations from the normal characteristics of the process, statistical processing of data, detection of trends towards deterioration and impact. In this regard, the application of control charts is related to:

- verification of the stability of processes;

- detection of deviations from the normal characteristics of the process;
- control of certain characteristics within the required limits;
- statistical processing of data, and detection of trends for the development of non-conformities;
- taking corrective actions;
- verification of the effectiveness of the actions taken.

Control charts are used when the values of the controlled quantity can be measured, as well as when only a qualitative assessment of the relevant parameter is performed, such as the presence or absence of defects in the product.

Construction of a control chart

For this purpose, a plan is developed, which is the basis for determining the frequency of individual samples and their volume.

The control chart is constructed by plotting the quality indicator under study on the ordinate axis. It can be the arithmetic mean ( ), median, range (R), standard deviation (s), number of defects, etc.

The abscissa axis shows the numbers of individual samples or the time when the control is performed.

The frequency of sampling depends on the controlled technological process, the duration and value of the control, losses when accepting defects, the nature of the process and production, etc. The sample is part of the controlled batch and depends on its size. A center line and upper and lower control limits are also plotted on the control chart. The center line is the required average value of the characteristic of the controlled quality parameter.

Types of control charts

Depending on the type of assessment, control charts are:

- control charts for quantitative (measurable) characteristics;
- control charts for qualitative (unmeasurable, alternative) characteristics.

Control charts for quantitative characteristics

Charts for statistical quality control by quantitative characteristic are used when the controlled parameters represent a continuous random variable with a normal distribution and the process is under statistical control. They represent a combination of two control charts, the combination being carried out in such a way that one of the charts characterizes the position of the center of grouping (Critical Index), and the other the dispersion of the process.

For quantitative characteristics, statistical process control is carried out using the following control charts:

 Xi – individual values;

 Xbar(S) – average with limits calculated based on the standard deviation;

 Xbar(R) – average with limits calculated based on the range;

 Xm(R) – mean with limits calculated based on the median;

 R – range;

 s – standard deviation;

 – arithmetic mean;

 /S – combined “mean/standard deviation”;

 X/R – combined “median/range”.

Control charts for quantitative traits with normal distribution have a centerline and two tolerance limits.

Tolerance limits can be determined in two ways:

 by experimental data obtained during statistical analysis;

 by standardization requirements, including the nominal value, tolerance T, the limits of the tolerance dispersion of Tg and Tg of the controlled characteristic and the acceptable defect level AQL (Acceptable Quality Level).

In the first way, the limits are determined on the basis of the actual dispersion of the values of the observed parameter and the characteristics of the process in a given time interval and are compared with its previous characteristics.

To determine the tolerance limits by experimental data, a preliminary study of the process is necessary, i.e. only after the implementation of about 10 samples can they be determined. These limits are not directly related to the tolerance

Tolerance limits allow monitoring the change in quality over time. Going outside the tolerance limits does not necessarily mean the appearance of a "marriage", but is a warning of deterioration in quality compared to a previous period of time. Some of the control charts by quantitative characteristics will be briefly presented:

- A control chart of individual values is distinguished by the dynamic nature of the tolerance limits. They are calculated for each sample depending on its volume.
- A control chart of arithmetic mean values (-chart) provides high accuracy and flexibility in reflecting changes in the process.
- A control chart of medians (x-chart) is easy to perform, since it does not require additional calculations.

- The control chart of the range (R-chart) is applied additionally to the above. It provides additional information about the dispersion in the samples.
- The control chart of the standard deviation (S-chart) is performed only with computer support.

In practice, a combination of two control charts is often used, one characterizing the process setting (X,), and the other its accuracy (S, R).

/S chart has basic statistical characteristics and s. This chart is somewhat sensitive to the influence of specific disturbances, causing significant deviations of single values from the average value for the process. By means of this combined chart, precise process control is possible.

/R-chart is similar to the previous one, but with the difference that instead of the standard deviation s, the range R is used to estimate the dispersion, defined as the difference between the largest and smallest values obtained in each sample. The range is an effective characteristic of dispersion, for small samples.

The application of control charts for quantitative characteristics is a prerequisite for maintaining constant quality, as well as for its continuous improvement.

Control charts for quality characteristics

For statistical process management, control charts for alternative characteristics are often used. These charts control several different, but independent quality indicators simultaneously by combining them into groups with equal importance of defects. Each inspected unit is assigned to the group "suitable" or "defective". Control charts for quality characteristics are:

 control chart for the relative number of defective products (p-chart);
 control chart for the number of defective products (np-chart);
 control chart for the number of defects (c-chart);
 control chart for the relative number of defects (u-chart).

The control p-chart is used when the volumes of the individual samples are different. The relative number pi of defective items in the samples, determined as the ratio of the number of defective items to the number of items in the sample, the center line, determined as the arithmetic mean value of pi, and the control limits are plotted on the control chart. The np-chart is similar to the p-chart, but for its use it is necessary that the volumes of the individual samples are the same. The number fi of defective items in the samples is plotted on the chart. The c-chart and u-chart are used when the number of defects per unit of item or per unit of length is not controlled.

GENERAL PROVISIONS

Quality management techniques are part of the toolkit.

They solve some of the quality management tasks, such as:

- Analysis of existing problems
- Systematization of problems into groups;
- Prioritization in the presence of many problems;
- Elimination of problems / cessation of new occurrence of errors.
- Visualization of problems (identification, presentation and evaluation of measured quantities)
- establishment of whether the causes of errors will occur or not
- Elimination of errors that occur due to inattention, intentionality, etc. may occur and confirmation of potential for improvement.

They are applied in all stages of the product life cycle and can be used both independently and in combination.

SEVEN CLASSIC QUALITY MANAGEMENT TECHNIQUES

In quality management practice, the seven techniques of Professor Kauro Ishikawa, which are called “classical”, are widely used, grouped according to their similar level of complexity. These are graphs, diagrams and flow charts, frequency map, histogram, Pareto analysis, cause-and-effect diagram, scatter diagram and control charts.

Pareto Analysis

The effectiveness of quality analysis depends on how much effort is focused on the most important problems. Experimentally, they can be identified using the Pareto diagram. It is named after Vilfredo Pareto (1848-1923), who discovered the law of disproportionate causes. According to this law, approximately 80% of the effect is the result of 20% of the causes of it.

Pareto analysis helps to identify the most important problems (those that Juran calls “essential”) and to concentrate efforts on solving them. The data is arranged according to certain criteria, e.g. frequency of occurrence, and is plotted as columns in a diagram.

They are divided into classes, e.g. A, B and C, respectively according to the frequency of occurrence of 70%, 20% and 10%. Class A corresponds to 70-80% of the dependent variable. Thus, the highest priority for eliminating problems and taking improvement actions is given to the so-called class A objects. Pareto diagrams can be divided into two types for phenomena and causes. The Pareto diagram for phenomena allows to find out what are the main reasons for the occurrence of certain phenomena in order to take measures to eliminate them.

The causes can be reduced to:

 workers (shift, age, qualification, experience, discipline, individual characteristics);

 raw materials (supplier, chemical composition, batch, type, manufacturer);

 machines and equipment (machines, standards, measuring instruments, units, techniques, etc.);

 working methods (technology, sequence of operations, organization and repair of tooling, etc.).

Pareto diagrams for phenomena serve to identify the most important problems to solve and can relate to:

 the cost of production (determination of losses from defective production, amount of losses);

 product quality (identification of defects, errors, failures, complaints and repairs that are most important);

 worker safety at work (identification of the most common accidents and incidents);

 deliveries (delayed deliveries, shortage of raw materials, difficulty in payment), etc.

Ishikawa diagram (Cause and effect diagram)

The “Ishikawa diagram” is named after the Japanese professor Kaoru Ishikawa and covers the mutual relationship of causes through a cause and effect diagram. It has a complex branched structure and is also called a “Fishbone” diagram. The construction of the diagram is carried out in the following sequence:

 the problem is defined (non-compliance with a quality indicator);

 the goal is defined;

 the dominant causes and their sub-causes are identified;

 the skeleton of the diagram is built with the recorded causes and sub-causes affecting the quality indicator under consideration

Histogram

A histogram is a technique for visually presenting the value of a controlled parameter or the frequency of its occurrence in specified intervals of change. It provides an opportunity for a quick assessment of the state, for example, of a process parameter relative to the target value and the type of distribution law. It can be used for both measurable and qualitative indicators. It is most often applied to parameters that are continuous in time.

Correlation diagram

The correlation diagram is used to graphically represent the relationship between two variables. It establishes the existence of a relationship (correlation) between the variables. In the presence of a clearly expressed relationship (linear, periodic), a mathematical model can be sought through regression analysis.

Control charts

The main tool of statistical control for the continuous assessment of the state of the process and its regulation are control charts. They are a technique by which the course of the technological process is monitored and allow for the timely detection of deviations from the normal characteristics of the process and trends towards such states.

Control sheet

The control sheet is used as a means of recording data in a simple and convenient tabular form. It is used in the analysis of defects, complaints, workload of technicians and people, etc. In this way, the raw data is converted into categories, for example, type of defects, causes of defects, time intervals, etc.

PRODUCT QUALITY ASSURANCE TECHNIQUES GENERAL

Quality management techniques are part of the toolkit. They solve some of the quality management tasks, such as:

- Analysis of existing problems
- Systematization of problems into groups;
- Prioritization in the presence of many problems;
- Elimination of problems / cessation of new occurrence of errors.
- Visualization of problems (identification, presentation and evaluation of measured quantities)
- Determination of whether the causes of errors will occur or not
- Elimination of errors that occur due to inattention, intentionality, etc. may occur and confirmation of potential for improvement.

They are applied in all stages of the product life cycle and can be used both independently and in combination.

TOOLS FOR IMPLEMENTING TOTAL QUALITY MANAGEMENT

Modern competitive market conditions place new demands on companies. Among the many concepts that have been developed in this regard, the concept of total quality

management (TQM) stands out as a modern approach to improving the competitiveness, efficiency and flexibility of the entire enterprise [Wildemann, H., Controlling im TQM, Springer, Berlin, 2015].

The founder of the concept of "total quality control" is A. Feigenbaum, who considers quality management as a function in the production system .

Later, W. Deming in the 1940s, J. Juran, K. Ishikawa, G. Taguchi and F. Crosby made major contributions to the development and application of the concept of total quality management. [Brückner Cl., Qualitätsmanagement - Das Praxishandbuch für die Automobilindustrie Carl Hanser Verlag GmbH & Co. KG, 2015].

The essence of the concept is that the organization must work not only on the quality of its products, but also on the quality of the organization as a whole, including the work of the staff. In this way, some dogmas of existing theories aimed only at product quality management are broken. Based on a literature review, the main aspects of TQM can be deduced as follows:

- policy, strategy and goals
- orientation towards personnel, which requires participation, stimulation and collective work on quality in all areas and at all levels of the organization;
- orientation to customers;
- Supplier orientation and integration;
- Commitment of management to create policies and programs aimed at total quality management;
- Continuous improvement and process approach.

The application of TQM principles forms a new management behavior that emphasizes the human factor, processes, management commitment and supplier integration, Customer orientation

In the TQM concept, quality is considered from the customer's perspective. Customer satisfaction determines the existence of companies and customers are the ones who ensure their work.

According to W. Deming, “Companies that are not able to have the ability to please their customers, it is better to cease their activities. Otherwise, they will have trouble with their customers... Satisfied customers also bring a lot of joy” [Deming, B.E.,K.Ed.Gahill The New Economics for Industry, Government, Education, MIT Press, 2015.]. For this reason, continuous research and evaluation of customer satisfaction is required.

Important sources of information are:

- conducting surveys;
- evaluating the results of consumer complaints;

 analyzing warranty costs, etc.

Consumer satisfaction is related to:

 recommending the organization's products;

 reducing marketing and advertising costs;

 increasing sales.

Orientation to the organization's personnel

The ability to meet consumer requirements can be ensured with the help of qualified human resources. Training and motivated personnel are an important factor in ensuring quality. In this regard, management needs to create a work environment in which its employees can work independently and be satisfied. The organizational structure must ensure creative participation of all employees[Manno, B.G., J.Kehoe, Managing Quality, New York: Philip Allan, 1550].

Based on programs for selection, growth, development, training and evaluation of the effectiveness of the training conducted, the personnel must be able to apply the principles of the TQM concept, such as:

 self-control and taking responsibility for the work performed;

 teamwork;

 initiating proposals for continuous quality improvement.

Supplier orientation

The quality of products and services is related to deliveries as an element of the production process. TQM requires trust in long-term relationships with suppliers, which is a prerequisite for the success of the organization. As a basis for this, it is necessary for suppliers to meet certain criteria, such as:

 proving high product and process quality, with the application of evidence, such as Declarations of Conformity, references, etc.;

 cooperation in the event of non-conformities in deliveries;

 correctness and corporate spirit when introducing new and improved products;

 commercial parameters – quantity, price, delivery term and conditions, guarantees.

Delivering deliveries just in time (just-in-time) and without discrepancies play an important role in the TQM concept, as the costs of incoming control and warehousing become unnecessary.

Responsibility of management

The introduction of the TQM concept is a strategic task of management, which can be successfully introduced only when it is initiated and supported by it. This requires that management has the necessary competence to be able to introduce it and serve as an example for the staff to gain trust and security. The main prerequisites for this are:

- understanding the content of the TQM concept as a factor for improving competitiveness;
- not to underestimate the costs of its introduction;
- not to delegate the task of “quality”;
- not to expect quick success;
- constant participation of management, providing information and consultation.

Continuous improvement and process orientation

Continuous improvement is one of the quality objectives set out in the TQM concept, which can be achieved by applying the PDCA - Deming cycle.

APPROACHES AND TOOLS FOR IMPLEMENTING TQM

A variety of models, techniques and tools are used in the field of implementing the TQM concept. Models, or awards (premiums) in the field of quality play an important role in the development of modern business, forming the philosophy of quality and the principles for improving organizations and their path to excellence. Thus, they are not just an assessment for recognizing merit, but a procedure that helps companies determine their achievements and shortcomings, their chances of success or tasks for the future. The difference between the approaches of quality management systems according to the ISO 9000 series of standards and those of the models of excellence is in their scope. The ISO 9000 series of standards provide requirements for quality management systems and guidelines for improving achievements.

The models of excellence contain criteria that allow for evaluation and provide a basis for quantitative comparison of its achievements with the achievements of other organizations according to BDS EN ISO 9000:2015, p. 2.12. [Zink, Kl. TQM als integratives Managementkonzept das EFQM Modell und Umsetzung mit Selbstbewertungsprozess, 2. Auflage, Hanser, 2004]. This is applicable to all activities of the organization and all stakeholders. Meeting the requirements for receiving the appropriate award represents the establishment of a total quality management system.

The main objectives of the awards are: applying the principles of the TQM concept; determining the basic requirements for building a competitive organization; exchanging information on the best business practices and business strategies. In order to assess effective

quality systems, a comprehensive nomination process and a set of criteria based on observations by quality experts are envisaged.

Awards can be given to companies, individual business units, public sector organizations, etc.

Modern quality management tools

In the history of quality awards, four widely known and recognized awards (premiums) play a key role: the Deming Quality Award; the Malcolm Baldrige National Quality Award; the European Quality Award, the National Japanese Quality Award, the Ludwig Price Award and other national awards.

The Deming Quality Award was established in 1951 by the Japan Union of Scientists and Engineers and is the highest award for the implementation of the TQM approach in Japanese companies. It is awarded annually in three categories: individual, applied award for a small company and the Deming model for large companies. The inscription of the Deming model reads: The right quality and equality are the basis for trade, prosperity and freedom.

The criteria for the Deming Quality Award are: policy and strategy, organization and its impact on quality, training and information, communication, analysis, standardization, controlling, quality assurance, effect and plans for the future. 90 points are given for the implementation of each criterion. The evaluation of the implementation of the requirements is made by the Deming Quality Award Committee.

The Deming Quality Award is an important prerequisite for quality management in Japan, which has made a significant contribution to the transformation of Japan into a producer of high-quality products and a leading industrial country.

The Malcolm Baldrige National Quality Award (MBNQA) of the USA was created after a careful study of the Japanese experience and the requirements of the Deming Award.

The implementation of the criteria of this award is considered a way to achieve excellence in management not only of companies, but it is also a management model for public, educational, religious and other types of organizations in the USA. This National Award aims to encourage quality improvement and to disseminate the experience of the awardees. It is named after Malcolm Baldrige, who served as U.S. Secretary of Commerce from 1981 until his death in 1987 and contributed to the introduction of

Modern Quality Management Tools total quality systems. An Award was established in his name in 1987. Nominations are made by representatives of the National Institute of Standards and Technology (NIST), the Department of Commerce, and the American Society for Quality Control (ASQC).

The Malcolm Baldrige National Quality Award review and evaluation are based on several key insights:

 quality is defined by the customer;

 management must establish clear organizational values related to quality and embed these values in the way the organization operates;

 excellence in quality comes from well-designed and well-functioning systems and processes;

 continuous improvement must be part of the management of all processes;

 companies must develop goals, as well as strategic and operational plans to achieve quality leadership;

 reducing response time in all operations and processes in the organization must be part of the quality improvement effort;

 operations and decisions must be based on data and facts;

 all employees must be trained and involved in the quality improvement effort;

 Designing for quality, as well as a subsystem for preventing errors and defects, should become a key element in the quality system;

 Organizations should communicate their quality requirements to their suppliers, striving to raise the quality levels of suppliers.

When evaluating organizations applying for the National Award, the following are taken into account: size and resources of the organization, number and types of employees, nature of the activity - products, services, technologies; special requirements of consumers and markets, size and type of the market: local, regional, national, international, as well as existing market regulations, the importance of suppliers and other external factors, as well as the influence that the organization has on them.

In 1992, American President George Bush Sr. added to the evaluation criteria: Quality management should not be viewed only as a strategic concept. Quality management should be viewed as a new style of work, which is expressed through a new way of thinking. The obligation to achieve quality goals and excellence is more than "Good practice" that becomes a way of life.

A key approach to total quality management within the European Union is the so-called European Quality Award.

The creation of the European Quality Award was initiated by the European Foundation for Quality Management, the European Organization for Quality and the European Commission.

The European Organization for Quality (EQ) includes over 30 national quality organizations, representing a large number of companies, institutions and individual members from countries in Europe. The EQ’s main mission is to support Europe in its efforts to increase

its competitiveness on behalf of the whole of society, especially in the conditions and challenges of digitalization [Chukalov K., Horizontal and vertical integration, as a requirement for cyber-physical systems in the context of industry 5.0, International Scientific Journal, Industry 5.0, ISSN 2543-8582, YEAR II, ISSUE 4/2017, pp 151-157]. To achieve its goals, the EQ promotes the exchange of information and experience on issues of total quality management, as well as quality training and qualification at all levels.

Individual quality awards are also awarded – such as the European Quality Award for Leadership in Total Quality Management.

In order to stimulate participation at a later stage, levels of participation are created as follows:

- “Committed to Excellence”, which involves the participation of organizations that have started and overcome the first difficulties on their path to excellence;
- Recognition of excellence, for organizations that have made significant progress;
- “European Quality Award” level.

The creation of three levels is believed to give the opportunity not only to the best, but also to a number of other ordinary organizations to strive for excellence.

As can be seen, the requirements for the award of the European Quality Award are grouped into 10 criteria, divided into two groups:

- Enablers, i.e. the approaches and the level of development of these approaches;
- Results, i.e. the results and the effect of these results.

ORGANIZATIONAL MATURITY LEVELS

The requirements for applying for participation in the Quality Awards are related to the self-assessment method. In this way, the degree of fulfillment of the Quality Awards criteria is determined.

In this regard, self-assessment becomes an important tool for the implementation of TQM and determining the level of maturity of the applicant organization.

Self-assessment is an overview of the achievements of the organization and the level of maturity of the quality management system.

The introduction of the TQM concept as a prerequisite for applying for a quality award is a process that goes through several phases:

- sensitivity phase;
- implementation;
- stabilization;
- perfection.

Each phase corresponds to a certain number of points on the way to TQM.

Covering all the requirements for receiving the relevant award represents the construction of a total quality management system

ECONOMIC ASPECTS OF QUALITY

Quality Costs

Intensification of competition in the market and increasing consumer demands regarding product quality have led to changes in the processes of quality assurance, as well as analysis and control of its costs.

Economic aspects are important for quality assurance, but difficult to analyze, since they do not always have quantitative measures, such as loss of image due to low quality, etc.

Costs from the perspective of National Accounting Standards are defined as "reduction in assets and increase in liabilities". In this sense, quality costs are involved in both the reduction of assets and the increase in liabilities in the enterprise.

Initially, the concept of "quality costs" was introduced in the USA in the thirties of the last century. The concept of "quality costs" is understood as all costs associated with obtaining, ensuring and improving quality. The definition of quality costs is closely related to their classification. The most widespread classification of quality costs to date is that of J. Juran, which he introduced in 1556. According to this classification, quality costs are:

- costs for preventive actions (Prevention costs)
- costs for quality control (Appraisal costs);
- costs for eliminating non-conformities (Failure costs) [Juran, J.M., F.M Gryna, Quality Planning and Analysis, 5rd Edition, New York: McGraw-Hill, Inc., 1552.].

In 1557, the classification was supplemented by R. Freman, who considered the costs of eliminating non-conformities that arise when quality requirements are not met during the production process (internal) and after the product is delivered to the customer (external).

Quality control costs are related to the activities of determining the degree of conformity of products within the framework of quality assurance. They include costs for:

- inspection of delivered raw materials and materials (incoming control);
- all control measurements of product/process characteristics;
- control during production;
- final control and testing;
- Management of monitoring and measuring equipment;
- quality assurance programs;
- comparison of quality with competitors on the market;
- quality documentation.

Control costs are related to the number of measurements, measurement time, cost of qualified labor and maintenance of measuring equipment. In this regard, there are opportunities to reduce the relative share of quality control and assessment costs in total costs by introducing sampling control, own control, flexibility in managing measuring equipment.

Costs for preventive activities are related to all activities designed to prevent damage and other losses in the production process. These include:

- quality planning (organizational quality assurance, product design, reliability studies, etc.);
- process control (study and analysis of process technologies, production process control, etc.);
- equipment design, use to obtain quality information (design of equipment used to determine the quality of production and the process, data collection, processing, etc.);
- training in quality assurance methods and personnel work (development of programs for training personnel aimed at the correct use of quality management methods);
- checking the design of products (before production evaluation of production);
- development of quality management systems and their improvement;
- Process management (costs for establishing process management tools, costs for studying process capabilities, costs for providing technical support to production personnel in implementing and maintaining quality procedures and plans);
- ensuring the quality of supplies (costs for evaluating potential suppliers and materials before concluding supply contracts, costs related to technical preparation of inspections and tests of purchased materials, costs for technical support of suppliers aimed at helping them achieve the expected quality);
- audit of the quality management system (costs for internal audit, for audit of the quality system by the user, his representative or other authorized body);
- other costs related to conducting preventive measures.

Costs during the production process (internal) are incurred to correct, rework or remove non-conforming products before they enter the distribution channels. This also includes costs from duplication of production activities, as well as defective work leading to scrap, including wasted materials and lost time of people and equipment. Additional work to correct and repeat production processes, re-inspection after corrections are made; re-qualification of defective products and their redirection for sale as “second quality” at a lower price. Also, deviations in quantities (excess inventory), often created to compensate for the “normal percentage” of scrapped products of non-conforming quality and analysis of the causes of non-conformities. The costs included in quality cover dynamic indicators whose impact on the efficiency of a product business is subject to the principle of the “iceberg of inefficiency” developed by Walter Masing.

QUALITY COST MODEL WITH ACCOUNTING FOR POTENTIAL COSTS

Potential costs are those that are related to consumer behavior, such as: consumer dissatisfaction, reduced willingness to buy and loss of potential consumers. In many companies, the costs associated with quality remain hidden or are so mixed up with other costs that they cannot be separated and recognized. Some of these costs, and in particular the more intangible "external losses" from quality failures, such as reputational damage and lost sales, are difficult to quantify, but nevertheless very real.

These costs should be included in the Quality Cost Model, as they are related to the degree of consumer satisfaction, as well as to their assessment of quality. The advantages of this model are the assessment of quality from the customer's point of view and its reporting is related to non-

Quality costs

0% 50% 100%

Quality level

Total costs with potential costs in mind

Total costs without potential costs in mind

Costs for non-conformities

Potential costs and costs for non-conformities

Costs for compliance with quality requirements

METHODS FOR ANALYSIS OF QUALITY COSTS

Depending on the goals, objectives and analysis of quality costs and the possibilities of obtaining the necessary data, various analytical methods are used. They differ depending on the stage of production and cost formation. One of the widely used methods for analysis and cost reduction is functional-value analysis. The method was developed during World War II at the General Electric Company.

Functional-value analysis (FVA) is a method for systematically studying the functions of an individual product or process, guiding the increase in the efficiency of resource use by optimizing the ratio between user properties and costs for its development, production and operation. The main principles of FVA are:

- a functional approach to the object of study;
- a systematic approach to the object and analysis of its functions;
- studying the functions of the object during its life cycle;
- valuation of each function;
- teamwork.

The manufactured products and their functions can be grouped as follows:

 the area of manifestation of the function in the interaction of the object with the external environment: internal and external;

 depending on the satisfaction of needs: main and secondary, such as the main function reflects the main purpose of creating the object;

 by importance for the work process, internal functions are divided into main and auxiliary;

 by the nature of manifestation, functions are nominal, potential and actual.

Nominal functions are set when creating an object and are mandatory for implementation. Potential functions reflect the possibility of performing functions when the conditions for its operation change. Actual functions are the actually performed objects of functions. All functions can be useful and useless, neutral and harmful.

The goal of FSA is to develop the useful functions of the object at an optimal ratio of their significance for the user at an optimal ratio of the costs for their implementation.

CONCLUSION

The requirements for individualized industrial products and services, together with the need for more efficient use of resources, flexibility and speed of production processes significantly increase the complexity of modern production systems, which poses new tasks in terms of the quality management toolkit.

The monographic study proposed an approach to systematization of techniques and methods in terms of their application.

A systematization of techniques for managing the quality of services based on their determinants was made.

A system navigator for the application of methods based on the Deming cycle, which has a universal character, was proposed.

It is argued that knowledge of quality tools is undoubtedly an important condition for its improvement, regardless of the field of activity of companies.

The use of methods and techniques for quality management, on the one hand, is associated with financial resources, as well as time costs, but on the other hand, it reduces discrepancies.

The author believes that it is possible that the problem will be discussed in more detail in the future. The quality of the product is of paramount importance for the production of any enterprise.

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