Machine-building enterprise performance and quality improvement tools

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Abstract. Mechanical engineering is the leading sphere in the industrial countries. The engineering enterprises products take the top place in a realization of the scientific and technological progress achievements in the all economy areas. The development of mechanical engineering is impossible without quality management system introduction at enterprises (hereinafter QMS), which aim is to improve technological processes, develop human resources, reduce production costs and improve competitiveness. This paper reviews the influence of quality management system on the technological efficiency of a machine-building enterprise. To effectively use the concept of total quality management (TQM), a model of a quality management system at a machine-building enterprise is proposed in four areas: quality, process, personnel and resource management. Defining the quality management concept of engineering products, current trends in the sphere of engineering enterprise development were classified according to the products life cycle stages. Developing the total quality management concept, machine-building enterprises should form their own quality concept and its continuous improvement, as well as product competitiveness. The product quality improvement concept should include an adaptation of the enterprise system model leading to the concept of total quality management.

1. Introduction

The products quality is the most important criterion of a machine-building enterprise activity, which determines its success indicators in the market. Trends of the product quality level increase are dictated by the survival tendencies in a competitive market, where the enterprise sets the pace of a production technological development, promotes innovation, accelerates the process of improving production efficiency, an appropriate policy of enterprise resource consumption is being implemented [1-4]. In the modern market relations, the competition between enterprises is growing at the level of product quality.

The concept of product quality is based on the state standard GOST R 53603-2009 "Conformity assessment. Product certification schemes of the Russian Federation".

The products quality and services of an organization are determined by their ability to satisfy consumers and by their deliberate or unintended influence on relevant stakeholders. A quality-oriented organization encourages a culture that is reflected in behavior, attitudes, actions, and processes that determine the value by meeting the needs and expectations of consumers and other relevant stakeholders [2, 5]. The quality concept is closely related to the concept of "a production technological
level" - a relative product quality characteristic based on comparing the indicators values that characterize the evaluated product technological perfection with the corresponding basic indicators and their values [6-8]. A product quality improvement in the sphere of the machine-building contributes to a significant economic renovation effect of all national economy sectors with new equipment.

When new machines are produced or previously manufactured ones are improved, when their quality system is being planned, it is necessary to use the machines quality indicators.

A quality standard indicator is a quantitative expression of one or more product properties relation to the conditions of the product manufacturing, operation and consumption [9].

There are two types of product quality indicators: individual and complex.

Individual quality indicators are related only to one of the product properties. Let's consider these indicators in relation to machine-building products. So, the internal combustion engine is characterized by the following individual indicators – power, speed, specific fuel consumption per power unit, etc. Individual quality indicators are used in the engineer’s products, when studying the characteristics of a new part or modernization of a previously mastered one, as well as during technical and technological control of their production.

Complex indicators are created for a complete assessment of the machine quality only by their most important properties, which are used in technical and economic planning of machine-building production to assess the quality dynamics for certain periods of time [10-12].

When the quality of machine-building products is considered, it should be noted that almost the entire organization takes part in the process of "the product quality creation". Thus, the concept of total quality management (TQM) was born. TQM is a quality-oriented approach to management, based on the participation of all organization members and aimed at achieving long-term success by meeting the needs of the consumer and benefits for all organization and society members.

This idea is considered as the most progressive and implies the active participation of each employee in the products quality improvement of machine-building production processes.

2. Engineering products certification

Certification of the machine-building enterprise products is a variety of these products quality assessment, which determines their compliance with the established requirements of specific standards or other regulatory documents. The product certification process does not show the quantitative level of quality or technical characteristics of an industrial product, but only confirms that produced goods meet the established quality requirements [8, 13, 14].

Products certification is divided into mandatory and voluntary. Mandatory certification is a state control over the manufactured products quality and safety. The certification boundaries are determined by mandatory standards.

Any product is a subject of the voluntary certification if its manufacturer intends to obtain certain economic benefits from this product type manufacturing, as well as to guarantee its export and competitiveness. A certificate of conformity is a document issued according to the quality management system certification rules to confirm that the certified product meets the established requirements. Issuance of this document type completes the product certification process.

In addition to the certificate of conformity, an industrial enterprise or company can receive a conformity mark confirming that the product meets the requirements established in the standards. National and foreign products certification is carried out according to the same rules and principles.

Certification in mechanical engineering is a very complex procedure that includes several stages. The main purpose of such control is to verify that a product of any category comply with norms and standards.

The basis of the Russian mechanical engineering products standardization system consists of technical regulations. So, at the head of products conformity verification in this industry there are the technical regulations that formulate safety requirements for machines and all equipment types [1, 15].
Quality and safety verification process of the manufactured products study such conditions that are created specifically for engineering equipment manufacturing, installation, transportation, also there are recycling requirements. At the same time, for some kind of machines is issued a certificate or a declaration of conformity [5, 16].

In addition, mechanical engineering certification is also checked by the emergency situations ministry. This confirmation of the safety compliance is mandatory only for equipment used in fire extinguishing. The fire safety certification is issued at the first stage of standardization by the certification departments since the permit document of the technical regulations system is issued only with the permission of an expert accredited by the Ministry of emergency situations [8, 17].

If the fire safety certification is not mandatory, the manufacturer has right to obtain a permit on a voluntary basis.

The product certification process includes: establishment of products range to be certificated, specific certification requirements determination of products types, introducing them in regulatory and technical documentation, development of documents establishing the rules for products certification, conclusion of product certification agreements, certification of exporting enterprises production, accreditation of testing organizations that conduct certification tests of products from the list, certificate registration and issuance, supervision and control over the certification correctness and certified products quality, as well as information about the results of certification.

In the practice of foreign quality assessment system are used several certification models types. The most popular type of them is self-certification, when the product manufacturer itself, without involving relevant certification experts, declares that its products meet all the requirements and norms of the standard. Such product certification system can be used only by a manufacturer with a perfect reputation.

However, an independent third-party certification system is the most popular among all certification systems. It has eight types.

The first type of certification system is based on the conducting standard experiments on product samples to meet the requirements of standards. Results of the experiments may prove or may not prove the submitted product sample conformity.

The second third-party type of the certification system is based on conducting experiments on product samples in specially approved testing organizations through periodic inspections of the product quality control.

The third type of certification system is based on conducting the same experiments as the first and second types, but with subsequent quality control of manufactured products, by periodic control tests of samples taken before sending them to the retail network [5, 18].

The fourth type of certification system includes conducting experiments on the product samples with subsequent products quality control by conducting periodic tests of samples that are taken from their production and trade spheres.

The fifth type of certification system involves conducting experiments on the product samples in specially approved organizations using evaluating systems to ensure product quality at the enterprise, followed by conducting periodic tests for samples quality control taken from the trade and production spheres. This system is the most complex, costly and expensive, but it receives a high level of distribution in industrialized countries and in international certification systems, because it provides to the consumer confidence of the product high quality level.

The sixth type of certification system implies only a preliminary assessment of the product quality assurance system at the enterprise. This type is used when the standard does not specifically regulate the requirements of final product quality, but only sets requirements for production process.

The seventh type of certification system is based on testing samples from each finished product batch. Their formation is carried out by special organizations, processing of test results using the mathematical statistics methods.

The last eighth type of certification system is based on testing each product for compliance with quality standards [7, 19].
The product certification process is preceded by the quality system certification process. The certificate of conformity of quality system is a document that verify quality system conformity to the ISO 9001 standard, which indicates the potential ability of the company to consistently produce high-quality products.

The main certification rules are defined by the international standard ISO 10011. The standard pays special attention to the qualification requirements for quality system inspectors (education, competence, work experience in a specific field of technology and in the field of quality assurance, personal qualities characteristics).

3. Implementation of a quality system concept at machine-building enterprises

Considering the problem of machine-building products quality management, it is necessary to take into account its impact on the production technical level in consumer industries. Also, it should be noted that machine-building products are always purchased by the customer to achieve their economic or social goals, so the customer achieves the planned results using machine-building products [9, 19, 20].

For effective use of the total quality management concept, based on the management concept developed by professor G. D. Segezzi at the University of Saint Gallen (Switzerland), the quality management system model at a machine-building enterprise in the quality management areas is proposed (table 1).

| TQM elements | Aspects | Components |
|--------------|---------|------------|
| Quality management levels | Resource standards: | Resource costs + quality concept. |
| 1. Normative level | - material; | |
| | - labour; | |
| | - financial; | |
| | - temporary. | |
| 2. Strategic level | Structure: | Time + strategy qualities. |
| | - organization; | |
| | - main production; | |
| | - auxiliary production; | |
| | - service farms; | |
| | - structural divisions of the quality management system. | |
| 3. Operational level | - activity; | Universal quality management + regulations + cost, quality and demand ratio. |
| | - staff behavior. | |

The quality management levels, aspects and components shown in table 1 are recommended for the use in TQM principles implementing at the enterprise that already have been tested abroad and have a certain positive result. At the same time, large machine-building enterprises use all TQM levels at the same time. Defining the quality management concept in the machine-building industry, it is necessary to classify current trends (table 2).

Thus, as an example of this concept application can be UZTM "URALMASHZAVOD", which produces and processes iron ore, steel casting, oil, natural gas products and coal mining. UZTM "URALMASHZAVOD" machines and equipment are used in 42 European countries, Asia and Latin America. Now the company is aimed at the welding production quality improvement. Introduction of
new innovative processes will improve the metal structures quality, thereby it will significantly reduce the work processes complexity. Standardization company is aimed not only at modernization of the welding production technologies but also at the welding production itself, which determines the quality improvement need of produced machines and parts.

| Products lifecycle stage | Modern tendencies in machine-building industry |
|--------------------------|-----------------------------------------------|
| 1. Design stage          | - equipment aggregation;                      |
|                          | - high-capacity aggregates creation;          |
|                          | - microprocessor-based systems management use;|
|                          | - resource saving;                            |
|                          | - ecological safety;                          |
|                          | - new materials use.                          |
| 2. Production stage      | - cooperation with other companies;           |
|                          | - complete equipment production;              |
|                          | - rotary and rotary-conveyor lines production;|
|                          | - new technologies use;                       |
|                          | - innovations dispersion.                     |
| 3. Exploitation stage    | - personnel training and retraining;          |
|                          | - follow the operating instructions for machines and equipment. |

To increase the efficiency of the plant’s production, there was made a decision to expand investment program by allocating additional funds for the technical welding production re-equipment and for the new quality management technologies and implementation of standardization. The implementation of new standardization processes and automation increase of the welding production has significantly reduced machining share in the field of metal structures production, which means overall decrease of work laboriousness (on average, from 10% to 15% for different technological processes) [7, 20].

Another one investment program that was aimed at standardization and product quality management, made it possible to purchase a spectrum analyzer for metals and alloys, which aim is to improve quality and to reduce production time of the final product. This device (price - 6.5 million rubles) was delivered to "URALMASHZAVOD" in September 2018. The unit is made in Germany. With the use of this unit you can easily check metal workpieces for quality standards compliance directly at the production stage, as well as increase the speed of their analysis. Before innovations were made, due to the lack of own chemical laboratory, verification of metals that were received from suppliers had to be ordered from third-party companies. This process was 2 weeks long, which was slowing the equipment production time. With a use of own testing device, the most complex analyses are performed for a maximum of 1 hour long time.

In order to achieve the total quality management concept, engineering companies must create their own unique quality management concept. In general, the proposed concept of improving the quality management of engineering products is based on the seven main standardization and quality management principles:

- principle of resources and transport services;
- principle of process technologies;
- principle of process equipment;
- principle of personnel training;
- principle of enterprise structure organization
- principle of enterprise structure management.
• principle of organization's culture creation and improvement;
• principle of relationships with suppliers and consumers.

4. Conclusion

Taking into account these principles, relationships between the supplier and the consumer should be based on compromises, while all logistics chain participants should have a limited profitability and efficiency level. This concept implementation should be considered by all participants of the technological process [9].

Influence sphere of the enterprise economic and technological interests covers the strategic, organizational and operational decision-making levels in the field of product quality improvement.

In the field of industry standardization the strategic decision-making level means the choice of activities, consumers, processes, suppliers. Therefore, when enterprise chooses suppliers, there are important such moments as their parts quality, flexibility and logistics chains reliability. The organizational level of standardization includes decision-making in the field of production and market organization, shipment warehousing methods. The operational decision-making level consists of the continuous production and products sales organization.

In our opinion, the concept of product quality improvement should include system modeling of a company that adapts total quality management concept [10]. This quality management concept definition for engineering products is most capacious, specific and takes into account all the features of it.

References

[1] Bondaruk A M 2017 Automated quality management systems in technological processes (Ufa: Monograph) p 144
[2] Efimov V V 2018 Quality management means and methods. Study Guide (Moscow: KnoRus) p 670
[3] Kibirev Yu V, Potemkina M V, Lontsikh P A, Livshits I I and Kunakov E P 2017 Process efficiency and safety assessment of engineering-construction organizations based on lean manufacturing Quality. Innovation. Education 8(147) 36-45
[4] Kunakov E P and Lontsikh P A 2017 The role of problematic personnel and increase of motivation in information security terms. Basic methods of working with personnel within the organization's information security system School of Graduate Students: Collection of Articles of the All-Russian Scientific Conference (Irkutsk) pp 44-50
[5] Livshits I I and Lontsikh P A 2015 Current certification analysis trends in the information security management systems according to the ISO 27001 requirements Bull. of Irkutsk State Technical University 3(98) 268-273
[6] Marquardt M 2017 The right questions - an effective management method. How leaders find optimal solutions by asking questions (Moscow: Omega- L, SmartBook) p 240
[7] Legal and regulatory technical documentation official website. Electronic Fund. Retrieved from: http://docs.cntd.ru/document/1200124393
[8] Serenkov P S 2018 Quality management methods. Risk management standardization methodology (Moscow: INFRA-M) p 221
[9] Khokhlova G I, Kretova N V and Sergeev V A 2018 Problems and factors affecting the development of innovation activities in Russia Management of economic systems 3 33
[10] Shishkin I F 2018 Metrology, standardization and quality management (Moscow: Standards) p 342
[11] Leonovich D S, Zhuravlev D A, Karlina Yu I, Govorkov A S and Karlina A I 2020 Automated assessment of the low-rigid composite parts influence on the product assemblability in the GePARD system IOP Conf. Ser.: Mater. Sci. Eng. 760(1) 012038
[12] Karlina A I, Gozbenko V E, Kargapol’tshev S K and Karlina Y I 2019 Methods for controlling the vibration state of technical facilities J. of Phys.: Conf. Ser. 1384(1) 012019
[13] Gozbenko V E, Kargapol'Tsev S K, Karlina Yu I and Karlina A I 2019 Approximation of amplitude-frequency characteristics using equidistants J. of Phys.: Conf. Ser. 1384(1) 012014
[14] Gozbenko V E, Kargapol'Tsev S K, Kuznetsov B O, Karlina A I and Karlina Yu I 2019 Determination of the principal coordinates in solving the problem of the vertical dynamics of the vehicle using the method of mathematical modeling J. of Phys.: Conf. Ser. 1333(5) 052007
[15] Kuznetsov B O, Gozbenko V E, Kargapol'Tsev S K, Karlina Yu I and Karlina A I 2019 Dynamic vibration protection of the railway carriage J. of Phys.: Conf. Ser. 1333(5) 052018
[16] Voropai N, Ukolova E, Gerasimov D, Suslov K, Lombardi P and Komarnicki P 2019 Simulation approach to integrated energy systems study based on energy hub concept IEEE Milan PowerTech 8810666
[17] Ilyushin P and Suslov K 2019 Operation of automatic transfer switches in the networks with distributed generation IEEE Milan PowerTech 8810450
[18] Suslov K, Solonina N and Gerasimov D 2018 Assessment of an impact of power supply participants on power quality Proc. of Int. Conf. on Harmonics and Quality of Power pp 1-5
[19] Konyuhov V Yu, Gladkih A M, Galyautdinov I I and Shchadova E I 2020 Calculations of efficiency in implementing progressive mold forming methods IOP Conf. Ser.: Mater. Sci. Eng. 760(1) 012027
[20] Konyuhov V Y, Gorban A V and Gladkih A M 2019 Investment in the improvement of maintenance service efficiency of processing equipment of an industrial enterprise J. of Phys.: Conf. Ser. 1353(1) 012102