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ANALYSIS OF CONTEMPORARY TRENDS IN FORMATION AND MONITORING OF QUALITY MANAGEMENT SYSTEMS AT ENTERPRISES

The study identifies the current trends in the formation and monitoring of quality management systems at enterprises. Based on the methods of comparative analysis, benchmarking, comparison and correlation the impact and effectiveness of quality management methods have been assessed and their overall effects have been analyzed.

Keywords: *management monitoring; quality management; competitive advantage; Pareto chart.*
JEL classification: M11.

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АНАЛІЗ СУЧАСНИХ ТЕНДЕНЦІЙ ФОРМУВАННЯ ТА МОНІТОРИНГУ СИСТЕМ МЕНЕДЖМЕНТУ ЯКОСТІ НА ПІДПРИЄМСТВАХ

У статті описано сучасні тенденції формування та моніторингу систем менеджменту якості на підприємствах. Використовуючи методи порівняльного аналізу, аналогій, порівняння та кореляції, проведено оцінювання результативності та ефективності чинних методів управління якістю, а також аналіз їх впливу у комплексі.

Ключові слова: *моніторинг управління; управління якістю; конкурентна перевага; діаграма Парето.*
Рис. 2. Табл. 1. Літ. 10.

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АНАЛИЗ СОВРЕМЕННЫХ ТЕНДЕНЦИЙ ФОРМИРОВАНИЯ И МОНИТОРИНГА СИСТЕМ МЕНЕДЖМЕНТА КАЧЕСТВА НА ПРЕДПРИЯТИЯХ

В статье описаны современные тенденции формирования и мониторинга систем менеджмента качества предприятия. Используя методы сравнительного анализа, аналогий, сравнения и корреляции, проведены оценка результативности и эффективности применяемых методов менеджмента качества, а также анализ их воздействия в комплексе.

Ключевые слова: *мониторинг управления; управление качеством; конкурентное преимущество; диаграмма Парето.*

Introduction. The problem of quality assurance of products and services primarily suggests the development of an efficient quality management system, which is critical for any area of economy, any company producing goods or rendering services, including education services. One of the priority principles of quality management stipulates the need of company's orientation at consumers, and on obtaining competitive advantage.

High quality of product may be achieved through the formulation of mission, vision and policy of an enterprise. Competitive advantage of the enterprise, evidently, depends on a reasoned and well-structured quality management system, with the implementation of the process approach to documented procedures. Standard ISO

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9000 defines the term of "process" follows: "Any activity or set of activities using resources to transform inputs into outputs".

Management system implies a structured integrity of mutually related and interacting types of activity, i.e. processes classified in a manner enabling to identify the added value and intended to accomplish the established goal – to create the conditions for the required quality of goods and services, while using the existing resources at minimal costs.

Brief literature review. Various aspects of quality management systems at enterprise have been reviewed in the studies by V.L. Veits et al. (2002), A.M. Egorov (2008), V.V. Kapyrin and G.D. Korenev (2002), P.A. Lontsikh (2014), P.A. Lontsikh and A.N. Shuleshko (2002). Basing on the analysis of a number of issues reviewed in the publications of the abovementioned authors, the present study analyzes the key trends in formation and monitoring of enterprise quality management systems.

The purpose of the study. Using the methods of comparative analysis, analogy, comparison and correlation the authors attempt to assess the effectiveness and efficiency of quality management, as well as analyze their impact in the complex.

Key research findings. In the process of universal spread of quality management, the International Organization for Standardization (ISO) published a series of international standards ISO 9000 in 1987, reviewed and re-issued in 1994. The current effective standard version was released in 2008.

It should be noted that international standard ISO 9001 requires that:

- its relevance is maintained;
- there are opportunities of its integration with other systems of management;
- an integrated approach to organization management is provided;
- a reliable foundation for application in the 10 following years is available;
- the ever-increasing level of complication in business environment of organizations is reflected;
- demands of all potential user groups are met;
- capacity of organizations to meet consumer demands is increased.

Based on the results of international polls, in 2013 the International Organization for Standardization (ISO) decided to review the ISO 9001 standards, and draft of the new standard version was published. The standard is expected to be released in 2015 (Veits et al., 2002).

ISO 9000 standards consolidate the international experience of setting up quality management by creating efficient quality management systems (ISO 9001, 2008).

Interests of business community in various standards for management indicates at, among others, the existing demand for certification services, which is capable of demonstrating to all stakeholders the compliance with the established requirements in a competent, unbiased, objective and independent way.

Statistics of the annual ISO study for 2011 published in December 2012 indicate that despite an insignificant decline of interest to certification according to ISO 9001 standard (more than 1,100,000 certificates were in force in 2011), growth of other standards remains quite high, being higher than the international economy growth rates (Veits et al., 2002).

Development of mechanical engineering leads to the acceleration of production processes caused by the obvious aim to increase efficiency and reduce production

costs. Alongside with that, requirements continue to increase in relation to implementation of quality criteria and dynamic parameters of enterprise equipment, to quality of operating machine tools, equipment, machines, and to quality of products, goods, management systems.

Table 1. **Statistics of the annual ISO study for 2011** (Zaitsev and Bochkarev, 2009)

Name of standard	Number of certificates in 2011	Number of certificates in 2010	Evolution	Evolution, %
ISO 9001	1111698	1118510	-6812	-1
ISO 14001	267457	251548	15909	6
ISO 50001	461	0		
ISO/IEC 27001	17509	15626	1883	12
ISO 22000	19980	18580	1400	8
ISO/TS 16949	47512	43946	3566	8
ISO 13485	20034	18834	1200	6
TOTAL	1484651	1467044	17607	1

Quality of products in commodity production is generally understood as the "integrity of typical features of form, external appearance and operating conditions, which constitute worthiness of goods". Requirements to provision of quality and dynamic parameters of enterprise equipment, quality of machine tools and equipment are appropriately reflected in quality indicators for each processed part, assembly unit or block. As applicable to machining process involving the use of metal-cutting equipment, requirements are established in relation to dimensions and shape of a product, microgeometry of processed surfaces, type and level of residual (process-related) stress. These are precisely the characteristics of parts, which determine the reliability of machine – its capacity to perform and preserve over time the required functions under given dynamic conditions of application.

Implementation of the abovementioned tasks is objectively related with the need to select the parameters of machining process considering the dynamic properties of technological systems. The definitive impact onto dynamic processes in the technological system is produced by the fundamental subsystem – metal-cutting machine.

One of the approaches, which may be used to analyze the dynamics of machine tools is the decomposition method. Various possible methods of decomposition in research of dynamics of vibroactive systems and in modeling of the analyzed system, have been consolidated into the general concept of a composite system. Computational schemes are built in a uniform abstract space of equivalent model flow charts of the analyzed system. This formalization, which is similar for a wide range of tasks, enables high degree of consolidation of final results.

Krone's diacoptic ideas and the developed theory of equivalent structural transformations of abstract models in space of full non-oriented and oriented static dynamic flow charts (Kapyrin and Korenev, 2002) are used as the theoretical basis for various decomposition interpretations of the calculation models in resolving technical and economic problems of various composition.

Preliminary analysis of the impact of dynamic characteristics of a vibroactive system onto the parameters of dynamic quality evoke the following general recommendations (Veits et al., 2002).

In static mode, this pertains to the following: quality requirements can be accomplished subject to high rigidity and avoidance of local deformations. The largest feasible cross-section should be selected to increase structural rigidity at bending load, and, in addition, thickness of external walls should be maximized by correlating possible changes with the level of inertial torque as an efficiency criterion for accomplishment of the necessary dynamic characteristics.

Most frequently, torsion torque appears due to action of a pair of forces, leading to deformation of the cross-section. In turn, this defect may be eliminated by adding a diagonal reinforcement, e.g. reinforcement ribs.

In a dynamic mode, preliminary analysis of the impact of dynamic features onto the system quality assessment requires the following to be determined:

- impact of change in structural parameters (mass, rigidity, additional reinforcement ribs) onto the change of first resonance frequency of bending and torsion oscillations,
- the ability to eliminate deformations of cross section during torsion oscillations by installing additional reinforcement ribs,
- elimination of machine tool's body wall oscillations by the installation of additional ribs.
- evaluation of the effect onto generation of the required dynamic parameters if the oscillatory system is supplemented with vibroactive systems powered by additional power sources enabling forming the necessary strength, rigidity, frequency parameters form, required damping parameters. Such systems may be applied to resolve the task of protecting equipment and structures from vibration and other impacts (Lontsikh and Shuleshko, 2002).

Technical indicators of systems described by their quantitative and qualitative parameters define the possible area of application and describe the main features of the machine tools' dynamic systems. These include the following indicators (Veits et al., 2002): process capacity of the machine tool, its accuracy, throughput capacity, economic and operational indicators of the machine.

Goals of the analysis include the identification of functional properties of machine tools and analysis of these tools by parameters. In the process, the following functional properties are distinguished (Veits et al., 2002):

- mechanical, defined by the conformity of load and tension to accomplish stable functioning of machine tools;
- metric (geometric), defined by the combination of relations between dimensions with consideration of pre-existing relations between them;
- kinematic, defined by the extent of approximation between movement or movement trajectory of one of the tool's elements and the required law of movement or trajectory;
- added work (or power) arising from the inaccuracy of parameters, causing degradation of machine tools' functioning;
- energy properties.

Functional analysis includes the completion of the following works:

- development of the kinematic layout of the machine tool, selection of the combination of quality indicators and limitations, formalization of machine tool's

operating principle (structural and parametric) with the use of functional analysis methods;

- mathematic description of machine tool's functioning and calculations to obtain the required result in the form of mathematical expression – the correlation equation. The obtained combination of correlation equations only holds true within the framework of the given machine tool's scheme;

- building a mathematic model of functioning is followed by stages of assessment, generalization and delivery of verification results. The mathematic model of functioning is used to confirm the nominal, limit and permissible deviation of dynamic quality indicator.

It is known that both quantitative and qualitative indicators of the machine's technical condition are distinguished. Determination of the machine's dynamic quality is one of the most critical tasks in monitoring and diagnostics of technical conditions. In the course of operation, structural parameters change continuously or stepwise from nominal to critical values. Therefore, indicators of dynamic quality of machines, their technical condition are determined by a combination of deviations in structural parameters of machine tools from their nominal values, which constitute the machine's normal operating conditions.

Changes in the structure of study object enables assessing the quantitative parameters of quality or technical conditions of machine tools in each moment of time. Variation of structural parameters of the research object has particular quantitative regularities, which may be defined in the course of diagnostics. Through accumulation, these changes may reach a certain quantitative limit, where quantitative change will occur.

Structural parameters of the object under diagnostics change in the course of operation, while regularity of the system in general and its functional quality degrade. Quantitative assessment of equipment quality and its technical condition is related to determination of regularities in changes of structural parameters under the impact of typical operational factors. These changes in structure of machine tools may be the following:

- natural wear, aging during normal operation;

- accelerated wear in case of violation of nominal operating parameters or use of non-permitted operation modes.

Therefore, change of machine operation quality indicators and their technical conditions is an objective process, which occurs under the impact of a wide range of operational factors and manifests a time-specific alternation of working, interim and fault conditions. Based on the above, the problem of machine tools quality assurance should be defined as solving the task of technical condition diagnostics and control of dynamic machine system parameters, which enable machine operation under normal mode while preserving the preset quality parameters.

Item 20.1 of ISO 9004 (ISO 9004, 2009) standard describes statistic methods as one of the key elements of quality management system at all stages of product life cycle, from setting the requirements at the beginning to satisfying these requirements at the end of the cycle. This leads us to the conclusion that documentation, which describes the application of statistic methods, is an efficient means of demonstrating that quality management system complies with the requirements of quality manage-

ment system contained in ISO standards, series 9000. In other words, "statistic methods may be considered an indicator (marker) of quality management system" (Egorov, 2008). 7 new methods or tools are used for the analysis of more complicated situations, along with the so-called problem solving methods, which all top managers should be familiar with. In particular, in the article "Statistic Methods. Staff Training Technology" (Egorov, 2008), the author states the following: "Popularity of statistic methods among Russian managers is growing, however, practical level of their implementation at present remains extremely low. The effect of the use of statistic methods on a company scale cannot be seen even if special tools are used". Indeed, much is being said about application of statistic methods, but very seldom can one come across information on their practical use at enterprises or organizations in Russia. Only individual examples of practical implementation of statistic methods of quality management are found in periodicals and Internet publications, and such examples are scarce.

P.A. Lontsikh and A.N. Shuleshko (2002) ground the motivation to apply Pareto charts as a tool in identifying the main problems and defects and distributing efforts to effectively solve these problems, to quantify the dependence of manufacturing defects and the possible effects on the quality of processes, their effectiveness. One of the tools of quality management is Pareto chart, which is based on the well-known principle of 20–80.

For process owners and stakeholders it is important to understand the root causes of discrepancies or defects. Pareto chart gives a clear ranking of the main causes of defect. Noting that chart, named after the economist and political scientist V. Pareto, is a type of graph that contains columns and line graph, where individual values are presented in descending order of the columns, and the cumulative sum of cumulative curve is presented.

Let us resort to the well-known bar graph or Pareto chart (Schumpeter, 2011).

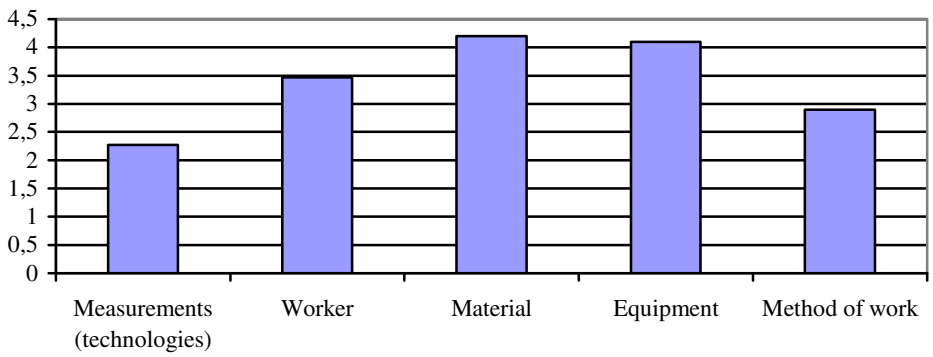

Figure 1. **Pareto chart of defect causes in material production,** *own research*

By comparing the provided data with the present state of the affairs in this area in our country, the status is estimated to be the equivalent of 30–40 years lag. Poor management is mentioned among the causes of this lag. This holds true for large enterprises as well as for small and medium business, where management commitment, rather than plain support remains at the top place among critical success factors of new systems application. Absence of this support, despite the initial enthusi-

asm of staff will lead to loss of motivation among staff and annihilate the entire potential of statistic management methods.

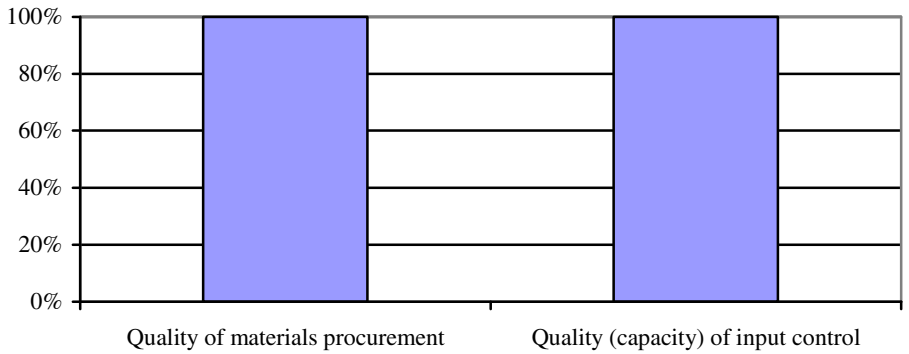

Figure 2. **Pareto chart of quality decline causes,** *own research*

We should note here that Shewhart control charts in management system is an effective visual tool, a graph of process parameters in time. The control card is used for statistical control process stability. Checklists were first introduced in 1924 by W. Shewhart in order to reduce the variability of processes by eliminating deviations caused no systemic reasons (Shewhart, 1939). To solve the problem of detection and prevention of shortcomings in specialist training, systematic statistic adjustment of the learning process with the use of Shewhart's control charts or Pareto charts is chosen. Method of statistic adjustment of the learning process and experience of its use in a higher education institution is represented with the target to accomplish and maintain the required level of specialist training quality. Correlation dependencies have proven to be an important statistic analysis of this orientation depending on the pre-set research task. A statistic research has been conducted, including primary processing of data and representation of results in the form of bar charts and graphs to the illustrate distribution of various indicators of the production technology process.

Conclusion. Therefore, the analysis of contemporary trends in formation and monitoring of quality management for enterprise results, first of all, has helped us assess efficiency and effectiveness of quality management methods used, along with their integrated impact. The necessity of the above is proved by close interrelation between quality management methods. At the same time, a number of methods may differ in terms of their impact on the formation of competitive advantages of enterprises.

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