Analysis of the formation and evaluation of performance indicators and efficiency of the organization's management system processes

A L Akhtulov, L A Ivanova and E B Charushina

1 Omsk Tank-automotive Engineering Institute, 644098, 14 military town, 119, Cheremushki vil., Omsk, Russia

2 Omsk State Technical University, 644050, Mira pr., 11, Omsk, Russia

E-mail: atulov-al1949@yandex.ru

Abstract. The article discusses some recommendations that will help organizations develop and implement their own methods for assessing quality management systems; a methodology for determining the effectiveness of processes is proposed. The main tasks for assessing the effectiveness of the quality management system are formulated and the selection of criteria for their significance is considered.

1. Introduction

The current state of the economy and the prospects for its development determine the growing interest in quality issues. Quality management is the main means of achieving customer satisfaction and maintaining the competitiveness of any organization [1-3]. In turn, the success of quality management directly depends on the ability to quantify (measure, evaluate) not only the indicators of product quality, but also the performance indicators and business processes and processes of the quality management system. Only the use of evidence and their analysis guarantee the correctness of management decisions [4, 5].

The first object to which quantitative methods for assessing quality indicators were applied was industrial production [6, 5]. Modern international standards in the field of quality management require focusing on the quality management system processes, and not only on their results, since the quality of the product as a result is a consequence of the quality of execution of all processes of the organization. Accordingly, the main task of specialists in the field of quality is to realize the possibility of a quantitative assessment of the quality of the execution of the processes entrusted to them [8].

Note that the most important indicators of the quality of process execution are their effectiveness and efficiency [6].

Thus, in order to control the quality of the process, it is necessary to be able to measure its effectiveness and efficiency.

2. Formulation of the problem

From the point of view of international quality standards, any activity is presented as a process (figure 1), which has inputs, resources, control actions and outputs [2]. The requirements of the standard are
aimed at ensuring that organizations evaluate the effectiveness of processes; the standard formulates recommendations for assessing the effectiveness of quality management system processes.

Therefore, to achieve success, it is necessary to provide inputs [9] that meet the requirements, the correct control actions [10], good resources [4], monitor and ensure the process characteristics at intermediate points [11]. Then the results of the process, i.e. its outputs will be correct, consistent with established requirements.

### 3. Theory

Let us imagine this figure in a different form (figure 2), in which the inputs, control actions (controls) and resources are shown on the left, and the outputs on the right. Below the rectangle depicting the process with inputs and outputs, in the upper row on the left is the rectangle “Planned Costs $C_{pl}$” - these are the costs associated with the organization of the process, for example, for the purchase of equipment, materials, regulatory documents, staff salaries, etc. On the right is the planned output of $O_{pl}$.

![Process Image](image)

**Figure 1.** Process image: 1-3 specific types of inputs; 4 - intermediate characteristics; 5 – outputs.

**Figure 2.** Recommended approach to the definition of the concepts of “effectiveness” and “efficiency” of the process.

| Input Process Efficiency | Relative process efficiency | Output Process Efficiency |
|--------------------------|-----------------------------|----------------------------|
| $P_{in} = Z_{pl} / Z_{f}$ | $E = U_{pl} / V_{f} = P_{in} P_{out}$ | $P_{out} = V_{f} / V_{pl}$ |

| Actual costs | Actual Unit Costs | Actual Product Release |
|--------------|-------------------|------------------------|
| $Z_{f}$     | $U_{f} = Z_{f} / V_{f}$ | $V_{f}$               |

| Planned costs | Planned Unit Costs | Planned output  |
|---------------|--------------------|-----------------|
| $Z_{pl}$      | $U_{pl} = Z_{pl} / V_{pl}$ | $V_{pl}$        |
If we correlate the planned costs $Z_{pl}$ with the planned output of $V_{pl}$ products, we can get the planned unit costs per unit of production ($U_{pl} = Z_{pl} / V_{pl}$). This indicator traces the relationship between the output of the process and the resources expended on its implementation, i.e. the value of $U_{pl}$ characterizes the planned efficiency of the process.

The ratio between the actual costs $Z_f$ shown in the lower part of the figure and the actual output $V_f$ gives the actual unit costs per unit of output ($U_f = Z_f / V_f$). Note that the value of $U_f$ characterizes the actual efficiency of the process.

If we compare the planned and actual costs vertically, then we get the efficiency of the process by input ($P_{in} = Z_{pl} / Z_f$). Moreover, if the actual and planned costs coincide, then the input efficiency will be equal to one, if the actual costs are less than planned, then the input efficiency will be more than one.

Let us similarly present the outputs: the effectiveness of the output process ($P_{out} = V_f / V_{pl}$) is the ratio of the actual output to the planned one.

The disadvantage of $U_{pl}$ and $U_f$ (characterizing the planned and actual efficiency of the process) is the dimension, more precisely, its presence. According to the values of $U_{pl}$ and $U_f$, it is difficult to compare different processes among themselves. From the theory of similarity, thermal physics, control theory, it is known that the best are dimensionless estimates. Therefore, there is a palpable need for some dimensionless indicator of the effectiveness of the process.

Since the planned and actual unit costs are dimensional estimates of efficiency, finding their ratio, we obtain the indicator "relative efficiency of process $E$", which, in turn, is already a dimensionless quantity

$$E = U_{pl} / U_f = R_{in} R_{out}$$

This dimensionless indicator of the relative efficiency of the process allows you to compare different processes (for example, the production process of a juicer with the production process of an electronic unit, the process of providing educational services at a university with the process of providing passenger transportation services, etc.)

Thus, the input data for evaluating the effectiveness and efficiency of the quality management system are: planned indicators (processes, products, personnel); actual (achieved) indicators (processes, products, personnel); planned resources and the result of their use.

Data for assessing the effectiveness and efficiency of the quality management system can also be: BSC data (balanced scorecard); evaluation data on premium models: Baldridge, Deming, European, Russian, Swedish, and others; assessment data of Certification Bodies (quality management system conformity assessment); assessment data of government organizations; organization self-assessment data; data from consumer and community ratings.

The output will be precisely: performance data and efficiency data.

In most cases, the assessment of the organization’s activities is based only on financial results. In the best case, BSC will be applied. But at the same time, monitoring of data obtained from BSC and quality management system is not done, and, of course, their analysis.

In the quality management system, an important role is played by criteria for ensuring the effectiveness of processes established by the organization, since the standard requires "to determine the criteria and methods necessary to ensure effectiveness, both in the implementation and in the management of these processes."

The role of the organization’s leadership is defined as follows: “One of the tasks of senior management is to conduct a regular systematic assessment of the suitability, adequacy, effectiveness and effectiveness of the quality management system taking into account quality policies and goals ... Analysis includes determining the need for action”.

That is, the management of the organization in which the quality management system is functioning needs to evaluate the effectiveness and efficiency of the quality management system. Here we can state that it is difficult to give really good examples. Main reasons:
• the mistake of the senior management that this is done by the head of the quality management system, and the director does not need it;
• underdeveloped budgeting and use of this data;
• formalism ("do it for auditors");
• poor staff training.

4. Results
Evaluating only performance or effectiveness will not provide complete information about the quality management system and processes. It is necessary to evaluate both effectiveness and efficiency. Conducting an incorrect assessment of the effectiveness and efficiency of the organization’s quality management system can lead to completely incorrect planning of the organization’s strategy and tactics.

The joint use of a balanced scorecard (BSC), key performance indicators (Key Performance Indicators - KPI) and criteria for quality management system processes - gives a real, objective assessment of the effectiveness and efficiency of the organization’s management system, and, naturally, quality management system.

The complexity of the problem of analyzing and evaluating the effectiveness and efficiency is associated with their multidimensional nature (we can consider these categories in relation to a product (service), process or system as a whole) and multilevel (company as a whole, structural unit, business process, workplace).

As the main arguments in favor of the effectiveness and efficiency of the quality management system, the following are usually expressed:

• cost reduction at all stages of the product life cycle (or cost reduction for "poor quality");
• increase in income (increase in market share and corresponding sales volume, including due to justified price increases);
• improving the manageability of companies by increasing the validity and efficiency of decisions.

Today, for most quality management system specialists, it is obvious that the effectiveness and efficiency for different stakeholders is different, that it is always a matter of some balance of their interests and a possible compromise. What to consider as a result and an effect is, first of all, a matter of the company's strategy. In principle, any indicators can be used to evaluate the effectiveness and efficiency of management systems.

Here are some examples of answers to these questions. In the American management system, the main performance indicators are traditionally determined by the owners of the companies, its shareholders. The main performance indicators are the financial indicators of the company's profitability in the future (market value of companies, economic added value, etc.). However, strange things begin next. Firstly, it turns out that according to very competent people, about 35% of all opinions of shareholders are based on non-financial information (strategy, management, organizational structure, quality, innovation, creativity, etc.). Further, the time interval at which the performance of companies is considered has recently increased significantly and, according to some estimates, has reached 30-40 years. This period of time during which the currently active population (including owners, investors, shareholders, investors, managers of various levels, etc.) will reach retirement age and will be able to count on a well-to-do old age. Today's world belongs to future retirees [8]! Given the specified time interval, the market value of the company, its capitalization, stock price and other indicators of financial well-being, we can consider as reflecting only the short-term tasks of the companies. By the way, the average "life expectancy" of companies is much less than the specified period and averages 12-15 years.

In other words, it is not the performance indicator as such that matters, but its strategic role and behavior over time (growth speed and acceleration). A similar approach was the basis of the
methodology for determining the effectiveness of system of quality, described in [10]. Obviously, the effect of any control system is inherently synergistic, i.e., the effect of enhancing the interaction and coordination between the elements of this system. The objective basis for the synergistic effect of the system is the real interaction of its elements. Two methodological conclusions can be drawn from this:

- the effect of the system is always greater than the algebraic sum of the effects of its elements;
- the effectiveness of the system is necessarily associated with determining the increase in the magnitude of the overall effect of the system compared to the total efficiency of the functioning of its individual elements.

5. Discussion of results
Monitoring the effectiveness and efficiency of the quality management system processes is necessary to assess the level of development of the system and its impact on the operation of the enterprise. In order to draw conclusions about the functioning of the quality management system, you must first measure the effectiveness and efficiency of each process (figure 3), and then, the results obtained, analyze and summarize (figure 4).

![Model for measuring the effectiveness and efficiency of the quality management system process.](image-url)

There are various methods for measuring the processes of an enterprise quality management system, which allow determining the effectiveness and efficiency of processes. The most common methods include the following:

- conducting internal and external audits (inspections) [12];
- analysis of planned and completed activities.

Checking allows you to:

- confirm compliance of the process with established requirements;
- identify the causes of inconsistencies;
- confirm corrective action;
- assess the degree to which staff understand the goals, objectives, and requirements established during this process;
- Identify ways to further improve the process in the quality management system organization.

![Diagram showing process flow](image)

**Figure 4.** Model for measuring the effectiveness and efficiency of the enterprise quality management system

Based on the results of the check, inconsistencies are determined and corrective actions are developed [13, 15], aimed at further improving the effectiveness and efficiency of the process. An analysis of the planned and completed activities allows the process owner not only to carry out the planning of the work on this process, but also to improve it by conducting a comparative analysis of the planned and completed activities, as well as to develop the necessary preventive and corrective actions aimed at achieving the planned goals.

It is also important to note that great attention must be paid to determining the period of analysis. The analysis can be: daily, weekly, monthly, quarterly, semi-annual, annual. The period of the analysis of the effectiveness and efficiency of the process is chosen by the owner of the process, based on the type of process, objective or subjective reasons, but not less than once a year. A correctly selected period of analysis of the functioning of the process allows not only timely identification of inconsistencies in the process, but also to prevent their occurrence. We will describe in detail each procedure of the model shown in figure 3.
Procedures for recording actual and planned criteria values. For each process, the owner of the process develops criteria and sets their planned values, according to which the effectiveness and efficiency of the process will be determined in the future.

The procedure for calculating relations is necessary to determine the relationship between the actual and planned values for each selected criterion [14]. These values will be used in the development of corrective and / or preventive actions to control the process.

The procedure for calculating the effectiveness of the process determines the effectiveness of the process [15], as the ratio of the sum of actual values to the sum of the planned values of the criteria.

The procedure for calculating the effectiveness of the quality management system process determines the effectiveness of the process as the ratio of productivity to the resources spent on the implementation of this process [16].

After there was a procedure for developing actions to improve the process. After an assessment of the effectiveness of the process was carried out on a weighting scale and conclusions were drawn based on the obtained value, the process owner proceeds with the development of corrective (preventive) actions, taking into account the relationship between the actual and planned value for each criterion. After determining the effectiveness of each quality management system process, they begin to determine the effectiveness and efficiency of the quality management system of the organization (figure 4).

At the output of each process, the value of the effectiveness and efficiency of the process is determined, which goes to the procedure for calculating the effectiveness and efficiency of the quality management system of the organization as a whole.

The effectiveness and efficiency of the quality management system organization is determined by the effectiveness and efficiency of the quality management system processes.

According to the procedure for developing actions, the representative of the quality manual generates corrective and / or preventive actions taking into account the value of the effectiveness of each process.

As a result of the implementation of this stage of the methodology, process owners will choose methods and criteria for measuring the effectiveness and efficiency of the process, and types of records of measurement results.

6. Summary and conclusions
Evaluation of the effectiveness of management systems in general and quality, in particular, is possible only on the basis of indicators that take into account the interests and degree of satisfaction of all interested parties, and in a strategic plan. Effectively, it contributes to the implementation of the strategy with respect to several or all interested parties at the same time, with the least cost of all types of resources and for a fairly long time. Activities cannot be directed only at consumers, shareholders, personnel or the company separately. This is a direct path to bankruptcy and, in any case, not the leader’s road. However, paradoxical as it may seem, the statement is true that almost any indicator used in management practice can act as an indicator of the effectiveness or efficiency of the management system. This, by the way, is one of the key principles of a balanced scorecard, however, only if it reflects the company's strategy and is used to evaluate effectiveness using some methodological techniques.

References
[1] Nive H R 2005 The space of Dr. Deming. Principles for building a sustainable business (Moskow: publishing house Progress)
[2] Ishikawa K 1988 Japanese quality management practices (Moskow: publishing house Economics)
[3] Akhtulova L N and Surtayev A M 2009 Identification of processes of a quality management system of an industrial enterprise Omsk Scientific Herald 75 pp 84–6
[4] Kulikovsky S A 2016 We select a methodology for assessing the effectiveness of the QMS. Guide to action Quality Management Methods 5 p 12
[5] Akhtulova L N, Dezhurova O V and Gruner D A 2009 Management of inconsistencies in serial production processes of an industrial enterprise *Omsk Scientific Herald* **83** pp 149–53

[6] Kovalev A I 2008 Performance, efficiency, productivity, or what the enterprise needs to measure *Quality Management Methods* **6** pp 24–9

[7] Kamyshev A M 2015 Evaluation and improvement of the effectiveness of the QMS according to the requirements of ISO 9001: 2015 *Quality Management Methods* **11** p 10

[8] Kirillov V I 2011 *Qualimetry and system analysis* (Moskow: INFRA-M: New Knowledge)

[9] Akhtulov A L 2005 Methodology and practical application of systems of automation of designing of transport machines *Bulletin of SibADI, Omsk* **3** pp 14–29

[10] Akhtulov A L, Ivanova L A and Charushina E B 2020 Method of quality assessment of design of complex objects in mechanical engineering *IOP Publishing ICMTMTE IOP Conf. Series: Materials Science and Engineering* **709** 022116 (doi:10.1088/1757-899X/709/2/022116)

[11] Akhtulov A L, Ivanova L A and E B Charushina 2019 Continuous improvement of engineering activities of the organization with use of cards of stream of value creation *IOP Publishing MIP IOP Conf. Series: Materials Science and Engineering* **537** 042067 (doi:10.1088/1757-899X/537/4/042067)

[12] Drucker P 2003 *Management Tasks in the 21st Century* (Moskow: Ed. house "Williams")

[13] Glichev A V 1983 *Qualimetry Applied Issues* (Moskow: Standards Publishing)

[14] Khvastunov R M 2009 *Qualimetry in mechanical engineering* (Moskow: Exam Publishing House)

[15] Ivanova L A, Charushina E B and Khodareva E V 2019 Of discrepancy prediction algorithm in the model of improve the quality of serial processes of engineering production *IOP Publishing APITECH-2019 Journal of Physics: Conf. Series* **1399** 033012 (doi:10.1088/1742-6596/1399/3/033012)

[16] Akhtulov A L, Ivanova L A and Charushina E B 2019 Measuring the effectiveness of the quality management system as a tool for improving the organization’s activities *IOP Publishing MIP IOP Conf. Series: Materials Science and Engineering* **537** 042059 (doi:10.1088/1757-899X/537/4/042059)