Automation of Quality Control Process without the Usage of Complex Information Systems

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Abstract. Brief analysis of the actual problems of modern quality management and the importance of product quality are highlighted in this article. An overview of the application of information technology in quality management and existing class of information systems that are used for quality control are given. Implementation of algorithm of quality control without the use of complex IS and the assessment of economic effect of the algorithm’ implementation are presented. Finally, a pathway for partial quality control automation without the usage of information systems is suggested.

1. Introduction

In the modern economy, the role of the quality of manufactured goods and provided services is increasing. This is confirmed by various studies. For example, a survey conducted in 2013 by the Russian Center for the Study of Public Opinion showed that “quality” plays a decisive role in the selection of food products for 29% of respondents (the highest result among the 7 factors presented in the survey).

However, it is worth noting that the “quality” of a product is a subjective concept, and it is quite difficult for it to quantify. Nevertheless, many “physical” characteristics, which often form the image of product quality for the buyer, can still be represented in numerical form [1]. For example, to determine the quality of technical devices, the mean time between failures is widely used [2]. Strict compliance of such physical characteristics with some reference—predetermined optimal—values is most important in the production of technically complex products. For example, it is known from open sources that more than 40 suppliers can participate in the manufacture of only relatively large components, assemblies and systems of a modern medium-haul aircraft. A malfunction (that is, none other than insufficient quality) of even one part of any such assembly or unit can lead to the removal of the entire aircraft from operation.

2. Quality Improvement Methodologies. Overview of the application of information technology in quality management

Technically sophisticated devices have recently become more commonplace with ordinary people (for example, mobile phones already mentioned earlier), turning from a “piece” product into a mass
product. This means that such devices must meet consumer expectations related to the reliability, functionality, etc. of similar products. In colloquial speech, the "quality" of a product is understood to mean precisely such a correspondence to expectations. Moreover, quality is important not only for technically sophisticated devices. In conditions of ever-accelerating informatization of society, even a relatively simple product can receive strong “anti-advertising” due to the presence of a defect. Thus, we can conclude that any company, any manufacturer or supplier needs to closely monitor the quality of its goods and services and take measures to increase it.

A new impetus to the development of quality management was given in the 1990s–2000s. It was at this time that information technology began to be used more and more to automate the workflow, plan the resources of enterprises, and so on. A number of IT-based toolkits for quality management have been developed. For example, among corporate information systems, a whole “integrator” class has appeared, called CALS (Continuous Acquisition and Lifecycle Support). Components of information systems belonging to this class allow you to automate the processes of development, production and output control of the product. Theoretically, the use of CALS systems can significantly increase product quality: as far back as the 1980s, it was noted that modern ICs at that time to automate development and production made it possible to reproduce an object 130 feet (~39.62 m) long in metal accurate to one ten thousandth foot (~0.000031 m). However, such systems have a significant drawback: they have a fairly high cost. For example, the fee for annual access to a set of software for computer-aided design and production, developed by Autodesk, is 103 687 rubles per job. Such a price is probably justified for large enterprises that produce technically sophisticated products, but smaller companies that produce simpler products may find it inappropriate to purchase such components of an information system. In cases where a relatively small enterprise decides to at least partially automate the quality management process of its products, such an enterprise faces the problem of choosing the appropriate path for this task.

3. Automation of Quality Control without the Use of Complex IS

Strictly speaking, it is possible to facilitate certain stages of quality management, for example, output control of product characteristics, without the use of any specialized IP. However, this will still require a testing station where quality control, scanners and measuring devices are carried out, the results of which can be accessed using telemetry methods. Obviously, computers are also needed for storing and processing information. The process of quality control of products of one kind can be performed as follows:

1. Upon receipt of the product at the test station, the scanner reads the serial number of the product;
2. The necessary product characteristics are measured (the simplest examples are mass and dimensions);
3. Through the selected programming language, access is made to the results of scanning the serial number and measurements;
4. Using a programming language, a connection is established with a relatively simple relational database, which stores the measurement results for each sample “visited” at the test station and, separately, the reference values of the product characteristics and allowable deviations from the reference;
5. Reference values of characteristics are requested from the corresponding table;
6. Calculate the deviation of the measured characteristics of the sample, which passes the quality control, from the reference values in percent or fractions \(1 - \frac{\text{value}_{\text{measured}}}{\text{value}_{\text{template}}}\);
7. Maximum permissible deviations are requested from the required database table, after which they are compared with deviations calculated in stage 6;
8. According to the formula for calculating the average value \(\bar{x} = \frac{\sum_{i=1}^{n} w_i \cdot |x_i|}{\sum_{i=1}^{n} w_i}\), the general measure of non-compliance of the sample with the standard is calculated (accordingly, a preliminary determination of the “importance” of each characteristic is necessary);
(9) If at least one of the characteristics has the deviation that exceeds from the permissible standard, or the general measure of non-compliance with the standard exceeds the permissible, the sample data (serial number and measurement results) are recorded in the report (in the simplest form, a text file);

(10) Using programming, all information about the sample is inserted into the database table, designed to store information about products tested at the test station.

The most difficult step in this algorithm is to establish a connection between the sensors and the software. The remaining stages are relatively common tasks in programming practice.

4. Some Aspects of the Implementation of the Algorithm

Let's consider the structure of the relational database mentioned in the algorithm in a little more detail. The authors suggest that such a database may include three tables. In one of the tables will be the reference values of the product characteristics that are checked during quality control. The number of columns in this table corresponds to the number of tested characteristics, and all values are probably stored as “floating point numbers” (float/double precision). The second table should store the maximum permissible deviations of the tested characteristics from the reference values in percent or fractions. Depending on the specific situation, the maximum deviation can be expressed either by one value (then the module of the calculated deviation should not exceed such a value; 1 column per characteristic) or by an interval (in this case, you can set different maximum deviations up and down; 2 columns per characteristic) Similarly to table 1, most likely, all columns will store values of type "floating-point number”.

Finally, the third—"main”—table should contain all the data obtained about the sample undergoing quality control. The following columns can enter the table structure: serial number (serves as the primary key), the results of measuring each characteristic of the sample, the deviation of each characteristic from the reference value in percent, the final measure of non-compliance of the sample with the standard and a mark on passing quality control (Boolean value). An example of how a similar table might look is shown in Fig.1.

![Figure 1](image-url)

General view of the table in which data on the quality control performed is stored. To illustrate, it is assumed that the quality of the eraser is measured with dimensions of 37.5 * 16 * 11.75 cm and a weight of 20 g. The marginal measure of non-compliance with the standard is taken to be 0.3%. Samples with serial numbers 11 001 and 11 006 did not pass quality control.

The data from this table can be further used in the general assessment of the effectiveness of quality management in the enterprise.

5. Economic Effect and Directions for Further Research

The cost of the proposed development should be relatively low. Among the costs can be distinguished: the wages of the developers themselves, the costs of retraining personnel conducting quality control, and overhead charges.

For the implementation of such an algorithm, the joint work of a system programmer and a specialist in RDB will be necessary. According to open sources, the average salary of such workers at the beginning of September 2019 was 150,000 and 100,000 rubles, respectively. Further, although quality control specialists will not need any special skills to work in such a program, you can additionally reserve funds equal to the salaries of both developers for the training of such
employees. Finally, if we assume that the building under development will be owned by the enterprise, the only type of overhead that affects the cost of changes is the cost of electricity. However, this cost component can be neglected. Even if computers of both developers work 24 hours a day, 7 days a week and consume 300 watts of energy (above the average), monthly payments for electricity will amount to (24 × 7 × 300)/1000 × 5.5 = 1227.6 rubles, where 5.5 is the cost of electricity per 1 kilowatt hour for individuals in Moscow. This means that the development process should take almost a year (which is extremely unlikely), so that overhead costs exceed the amount of 10,000 rubles. Thus, the cost of electricity from the calculation can be excluded. As for the development time, a period of two months should be more than enough to put the industrial version into operation. Thus, in the worst case, the cost of developing and implementing the described quality control automation algorithm will be (100,000 + 150,000) × 2 + 250,000 = 750,000 rubles. It is worth noting that the company will receive software that can be used on as many workplaces as you like without buying any kind of license. Moreover, if the selling price per unit of production is 10,000 rubles (a very reasonable price for furniture, for example), then selling only 75 products that have successfully passed quality control will pay for the development.

6. Conclusion

Although the algorithm presented in this paper is presented in a fairly general form, it still shows that the purchase of expensive components of information systems and other proprietary software products is not always necessary. As a recommendation for further research, the authors suggest exploring the possibility of using “home” development software in other areas of quality management, and not only during the output control of products.

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