

## Quality assurance of technical specification approval process

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**Abstract.** The paper reviews the issue of increasing the efficiency of contract analysis on machine-building plants in accordance with process approach principles and on the basis of better interaction between marketing, finance and accounting, and R&D departments.

### 1. Introduction

Modern industrial machine-building plants with annual production output exceeding 130 mln US dollars operate in the conditions of job order production where the order serves the basis for production planning. A distinctive feature of such production is continuous reduction of time required to take any organizational and technical decision, for example, to assess the rationality of accepting any technical order for execution. In that case, the management of orders resulting in maximum production efficiency becomes the most critical task of any plant. This process includes subprocesses covering procedures on acceptance, preparation, transfer, processing, and monitoring of the order. Such procedures take 50 – 70% of the total time of order execution. Therefore, the quality improvement of customer service shall be reached through the reduction of time for these procedures driven by more efficient management.

The key subprocess of order management includes approval of technical specifications, which results in identification of high quality production resources as may be requested by the customer, and hence fosters the decision on accepting or rejecting an order with subsequent product delivery contract. The approval of technical specifications entails determination of customer requirements to production, correlation of such requirements with service properties of industrial products, assessment of technical and economic hardships caused by replacement of service properties of basic industrial products design matching the customer needs, determination of estimated price of the contract and development of recommendations for order acceptance or rejection. The analysis of technical specification approval is ensured at the stage of receiving and studying the request for contract or draft agreement; during fulfillment of a formal contract; following the results of contract fulfillment as statistical data for marketing information, and in case of complaints (claims) for production.

The approval of technical specifications at industrial plants is made jointly with their marketing, finance and accounting and R&D departments. First, upon comprehensive consideration of an order, the marketing department transfers order specifications to R&D department for further decision on the possibility to implement an order, terms and cost of its production. Then, the finance and accounting department determines the final price of production based on conclusions made by marketing and R&D departments [1]. There is a risk that the marketing department, in its strive to leverage the competition, may take a sudden decision to accept an order not estimating opportunities and resources of a plant, thereby causing problems not only for itself and R&D department, but also for the entire plant. In order to avoid this scenario, the marketing department shall work closely with R&D and



finance and accounting departments, which will quickly analyze a possibility of implementing terms of the contract and set its price.

At many industrial plants, the approval of technical specifications is made manually, which leads to failures in procedures and increase in the overall order cycle time. Such failures to assess the need of accepting an order may result in economic losses. In case of under-resourced order, the plant bears losses related to the increase in production cost, uneven work of its divisions, possible fines and penalties imposed by the customer for poor quality of production and violations of its delivery terms. In case of unreasonable rejection of an order, the plant bears the corresponding losses due customer disloyalty. Thus, the purpose of studying the terms of contract includes compliance of plant opportunities with customer requirements and definition of mutually beneficial conditions for contract fulfillment.

Multifunctionality of approval causes the need to improve its efficiency through advantages of modern management, including quality management, which implies process approach principles and standardization of corresponding activities [2, 3]. Therefore, it is critical to solve the task of improving the efficiency of approvals at machine-building plants following the process approach principles due to better interaction between marketing, finance and accounting, and R&D departments. At the same time, the important role of approving technical specifications within the process network of a plant producing technical systems makes it critical.

## 2. Materials and methods

In order to solve the task, the paper covers identification of relevant characteristics of technical specification approval [4] according to the concept of process approach, determination of priorities in administrative tasks within corresponding departments of a plant and interpretation of the Deming cycle (Plan-Do-Check-Act) [5], including planning, performance, control of their execution and regulation for the benefit of managing the aforesaid process (Fig. 1).

Structural and functional modeling in production conditions of LLC Uzlovsky Machine-Building Plant [4] was also carried out alongside with analysis of process stages which imply interaction between marketing, R&D and financial and accounting departments when determining customer needs, required types and volumes of resources and the contract price. It is advisable to implement this mechanism aimed at improving the efficiency of interaction on the basis of Quality Function Deployment (QFD) and Taguchi Loss Function. In this case, it will be possible for a plant to compare customer requirements with available resources and design base.

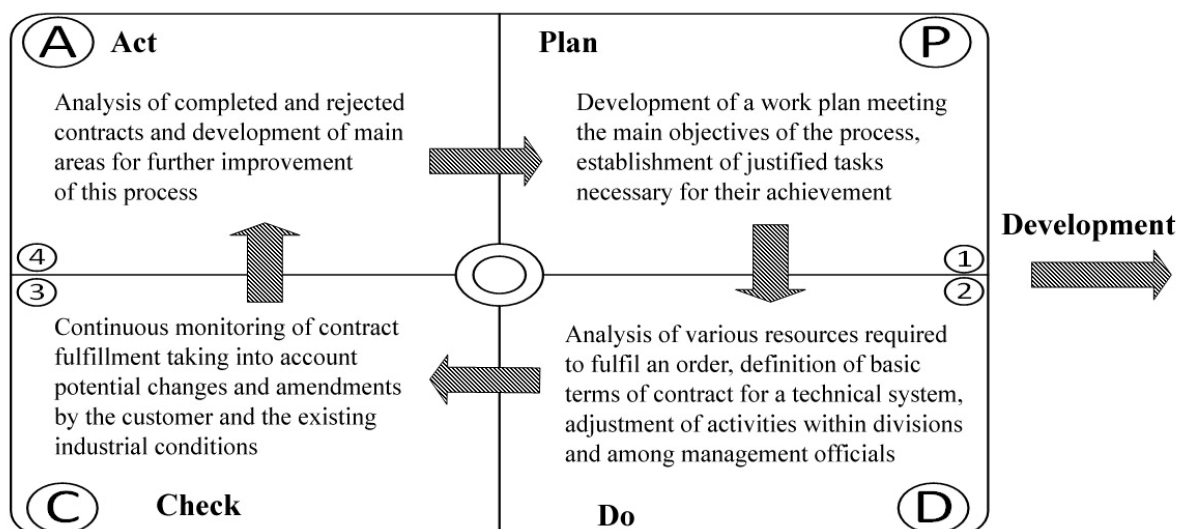


Figure 1. PDCA cycle

The QFD method ensures coordination of plant opportunities with customer requirements, as well as conditions favorable to both parties [6]. The implementation of this method is presented as the “quality house” that includes customer requirements to production output (using the example of lifting machinery) and degree of their importance, service properties of industrial products, interrelation of customer requirements with its service properties, interrelation of its service properties, production profiles of a plant and its main competitors, technical difficulties of changing service properties of basic design with regard to customer requirements, and, finally, the design task considering the compliance of service properties with customer needs [7].

The QFD method is based on customer’s voice regarding properties and characteristics of production output, determination of its main service properties meeting customer requirements, and quality analysis of production output of a plant and its competitors [8]. The information required for this purpose may be obtained through on-line questionnaires of customers and manufacturing experts on the Internet. In this respect, by means of a free on-line questionnaire service, for instance, Anketolog (<https://anketolog.ru/survey.html>) the corresponding questionnaires were developed and surveys of customers and representatives of relevant departments of a plant were conducted. The processing of data thus obtained is ensured by qualimetry (expert method).

The example of the “quality house” at bridge crane production is shown in Figure 2 [7]. The following is understood as consumer requirements: CR1 – crane type, CR2 – loading capacity, CR3 – span, CR4 – operating temperature, CR5 – placement, CR6 – operating mode, CR7 – control, CR8 – design, CR9 – price, CR10 – lift height, CR11 – control system, CR12 – load lift speed, CR13 – travel speed, CR14 – crab travel speed. The following is understood as basic design characteristics: DC1 – design material, DC2 – design basis, DC3 – electric motors, DC4 – gears, DC5 – brakes, DC6 – transmission elements, DC7 – power equipment, DC8 – control cab, DC9 – control switch, DC10 – block-and-tackle system, DC11 – running wheels, DC12 – safety devices, DC13 – railing, DC14 – galleries, platforms, ladders.

The cost of production contract is defined by Taguchi Loss Function through correlation of customer requirements with basic service properties of production [9, 10]:

$$L(y) = c(y - y_0)^2,$$

Where  $L(y)$  – cost losses due to deviation of service property values of industrial products from values of the same property referring to basic industrial production;  $y$  – service property against customer requirements;  $y_0$  – service property value of basic industrial products;  $c$  – coefficient characterizing money equivalent, which can be defined if costs associated with losses  $S$  are known at maximum possible deviation of service property value upon customer requirements from basic property  $\Delta = y_{\max} \pm y_0$ . In this case  $L(y) = S = c(y - y_0)^2 = c\Delta^2$ . Then  $c = S/\Delta^2$ .

Calculation of quality loss function during approval of technical requirements for industrial products can be as follows: since the entire activity of a plant is aimed at greater compliance with customer requirements, the manufacturer either fully meets such requirements, or suggests improvements of some service properties of industrial products. Therefore, it may be accepted that the customer, in case of strict compliance with design documentation, does not bear any additional costs alongside with price and fixed operational costs of purchased industrial products. Hence, only losses of a manufacturer, for whom it is necessary to evaluate contract efficiency as soon as possible meeting various customer requirements, shall be considered.

Any dispersion of service properties of industrial products regarding service property values of basic production leads to some particular costs of a manufacturer. Such costs may vary from simple inconveniences to financial damage.

Manufacturer’s costs may be caused by the fact that the  $i$ - value of service property  $y_i$  required by a customer differs from its basic value  $y_{0i}$ , no matter how irrelevant such deviation is. The loss function reaches its minimum at  $y_i = y_{0i}$ .

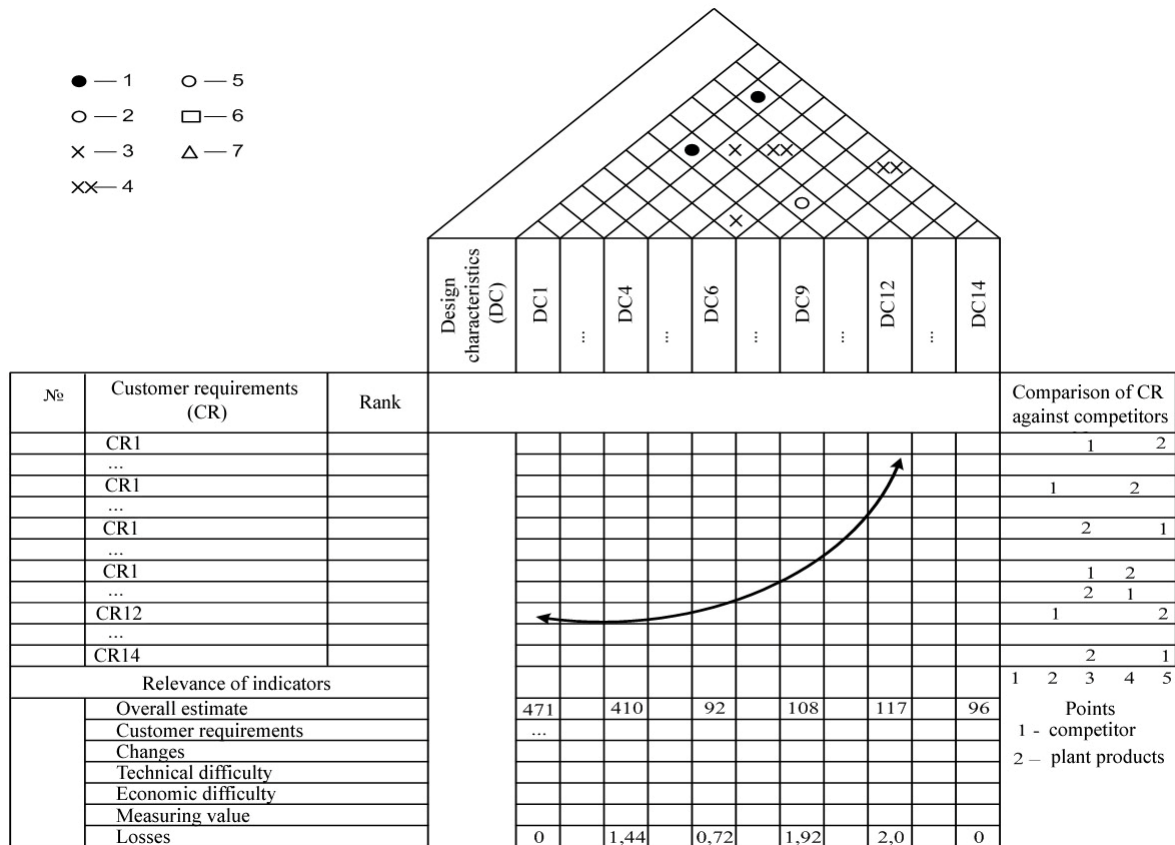


Figure 2. Quality House

The value of coefficient  $c$  is determined due to the following reasons. There is corresponding change limit  $\Delta_i$  which is estimated in points from 0 to  $N$  (0 – changes are not needed,  $N$  – huge and complex changes are required) for all service property values of industrial products within the “quality house”. Within this study,  $N = 5$ . Any deviation from basic service properties leads to additional costs  $S$ . Then:

$$c = \frac{S}{\Delta^2} = \frac{S}{5^2} = \frac{1}{25} S .$$

The final loss function for each  $i$ -service property taking into account comparison of basic values and customer requirements is presented as follows:

$$L(y_i) = \frac{1}{25} S (y_i - y_{0i})^2 .$$

Total costs considering deviations of all service properties from properties of basic industrial products represent the sum of cost production of every service property change per technical difficulties associated with such changes:

$$L(y) = \sum_{i=1}^n T_i \cdot L(y_i) = \frac{S}{25} \sum_{i=1}^n T_i (y_i - y_{0i})^2,$$

where  $n$  – number of service properties of industrial products within the “quality house”.

Technical difficulties associated with change of service properties of basic industrial products regarding customer requirements are assessed through an expert method and placed in the lower part of the “quality house”. At the same time, technical difficulty  $T_i$  of shift of  $i$ -service property towards the required direction is assessed in points and may vary from 0 to 5.

Economic evaluation of one unit difficulty of service properties shifts towards the required direction and defined by either an expert method or is set by financial and accounting department of a plant. Economic evaluation of one unit difficulty can be determined through the comparison of production cost of two technical systems with different designs regarding some indicators.

The determined losses lie within the interval of  $L_{\min} \leq L \leq L_{\max}$ . The manufacturer costs will be minimum if the customer buys industrial products with basic design, and such costs will be maximum if the necessary changes of all properties with technical difficulties of service property shift towards the required direction are scored 5. Experts set limits  $L_1$  and  $L_2$  for manufacturer costs used for recommendations regarding order acceptance or rejection. If the costs lie within the interval of  $L_{\min} \leq L \leq L_1$ , the order is accepted, if the costs lie within the interval of  $L_1 < L < L_2$ , the order might be accepted provided the marketing department consults the financial and accounting and R&D departments, as well as upon joint negotiations with customers. If the costs lie within the interval of  $L_2 \leq L \leq L_{\max}$ , then it is advisable to reject an order or, in exceptional cases, to accept it at a considerably higher price.

Thus, when receiving a contract order, the marketing department of a plant may quickly estimate the advisability of accepting an order, comparing service properties of industrial products required by the customer with service properties of basic products manufactured at the plant.

### 3. Illustration of the method of estimating model parameters

The information support system and the methodology of corporate standard *The Procedure for Technical Specifications Approval* was developed to ensure quality control of technical specification approval within a machine-building plant and to provide a sound solution for accepting an order for industrial products. The designed information support system used for questionnaires is based on the database comprising respondents of industrial plants and their responses contained in corresponding tables “Questions”, “Plants” and “Reports”. The corresponding questionnaire forms are developed in order to complete tables with relevant information and to extract the required information from the database. The report containing customer responses is made on the basis of the table “Plant”.

The updated information is included into a subsystem “Analysis of contracts” together with values of customer requirements, relevancy and calculation of quality loss functions.

The obtained QLF values, depending on customer needs, serve the basis for decisions regarding contract efficiency and future work taken by the marketing department.

### 4. Conclusions

Practical application of such information support system to control the approval of technical specifications within machine-building plant and to foster the decision regarding acceptance of the order for industrial products in LLC Uzlovsky Machine-Building Plant reduced the approval time by 23% and increased the amount of concluded contracts by 17%. The approval of technical specifications within a machine-building plant is specified in the corporate standard *The Procedure for Technical Specifications Approval* being an integral part of the quality management system complying with GOST R ISO 9000 requirements.

## 5. Acknowledgments

The results of the research project are published with the financial support of Tula State University in the framework of scientific project No. 2017-17PUBL.

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