A methodological approach formation to assessing the compliance degree with the requirements and the achieving it cost at the product life cycle stages

A V Kirov

MIREA - Russian technological university (RTU MIREA), 78, Vernadsky Ave., Moscow, 119454, Russia

E-mail: glarbb@mail.ru

Abstract. Currently, industrial enterprises and operating organizations is in the development process and the products' system life-cycle management formation. In this system, the compliance assessment and cost analysis on product quality are the main objectives. Under ISO 9000 series standards, product cost assessment is one of the enterprise quality management system basic elements. To do this, product quality costs must be set, processed and analysed in the same way as other costs. At the moment, there are different approaches to determining the quality products cost that is not effective enough. The presented work has developed a methodical approach that can be applied in assessing the products' life cycle total cost and determining the "price-quality" effectiveness type.

1. Introduction
The design process, development, production, operation, handling and disposal of products is its life cycle (LC). It lasts from the need justification moment for production and research and development (R&D) up to the last copy decommissioning and disposal.

Product LC management is carried out using a management complex, engineering and information technologies, which include configuration management, requirements management, integrated logistics support, project management and LC cost management [1,2].

Therefore, when planning and implementing the product's lifecycle, it is necessary to justify planned and management solutions for all stages more carefully before proceeding with their implementation. It should be noted that at the life cycle each stage there is a product changes specific process, various relevant resources are spent, a factors' certain group is in force, there are the life cycle peculiar conditions and patterns, as well as their risk factors are manifested. Each stage is characterized by its own goals, decisions and objectives to achieve goals, and their process quality indicators and decision-making criteria are used [3, 4].

Groups such as a group of quality parameters, cost groups and time parameters can be classified as the life cycle parameters main groups (indicators) that require constant monitoring and targeted impact on them in the life cycle implementation process.

Currently, important economic categories such as production efficiency, costs, price and profitability are increasingly correlated with product quality indicators. Therefore, an important element in the product life cycle analysis is to assess the compliance degree with the product requirements and the achieving it cost at the life cycle main stages, which is what this article is devoted to.
2. Material and research methods

As a basis for the developed methodical approach to assessing the compliance degree and the achieving it cost at the product life cycle main stages, we will offer a feasibility study method based on a results' comparison (effects) achieved in the specific tasks performance and costs spent (lost) in these tasks course. The main criterion for assessment is determined by the formula:

\[ G = \frac{C_{st}}{E_{st}} \rightarrow \min, \]  

where:
- \( C_{st} \) - the costs spent on the task;
- \( E_{st} \) - this task effect (result).

The technical and economic analysis objectives in assessing consumer utility (the compliance degree with the requirements) and the achieving it cost at the product life cycle main stages are:

- the product life cycle marginal total costs (appropriations) determination using this cycle integrated management methods;
- limit prices determination for newly developed or upgraded samples at the specified analogues;
- revealing the various factors influence on the economic efficiency level and the product limit prices;
- the various products comparative effectiveness determination when performing specific tasks;
- product quality functions construction for their further use for the decisions' feasibility study purpose taken in the development management, development, procurement, operation and disposal [5-7].

When calculating the limit price of this estimated \( i \)-th sample in the \( j \)-th problem, the form criterion (1) is presented in the form (for a given base and estimated \( i \)th option):

\[ G_{b_j} = \frac{\alpha_{b_j} \cdot P_b + E_{other}^{b_j}}{E_{st_b}}, \]  

\[ G_{i_j} = \frac{\alpha_{i_j} \cdot P_j + E_{other}^{i_j}}{E_{st_j}}, \]  

where:
- \( G_{b_j} \) and \( G_{i_j} \) - values of the \( G \) criterion for the basic and \( i \)-th variants in the \( j \)-th task;
- \( \alpha_{b_j} \) and \( \alpha_{i_j} \) - coefficients at the samples price, with which it is included in the total cost for \( j \)-th task;
- \( E_{other}^{b_j} \) and \( E_{other}^{i_j} \) - the “other” costs values not related to the price in the \( j \)-th task, respectively, for the basic and \( i \)th options.

In the general case, of course, \( G_{b_j} \neq G_{i_j} \).

having found the upper price limit at which \( G_{i_j} \left( P_{i_{max}} \right) \) will be equal to \( G_{b_j} \), we will find the required value of the limit price of \( i \)-th sample concerning the base in the \( j \)-th task. That is, from the condition:

\[ G_{i_j} = \frac{\alpha_{i_j} \cdot P_j + E_{other}^{i_j}}{E_{st_j}} = G_{b_j}, \]
follows

$$P_{ij}^\wedge = \frac{G_{bj} \cdot E_{ij} - Ex_{ij}}{\alpha_{ij}}.$$  \hfill (5)

The indicator $G_{bj}$ can be selected either according to some fixed or hypothetical model, taking into account obsolescence various factors.

When comparing samples on tasks set performed by them, the total integral value of the limit price of this i-th sample can be determined by the formula:

$$P_i^\wedge = \sum_j k_j^a \cdot P_{ij}^\wedge,$$  \hfill (6)

where:

$k_j^a$ – the weight coefficient or the given problem relative frequency.

In general, different comparison bases can be used for this sample's different tasks.

Having the products' limit prices indicators value and their production cost value, it is possible to construct a "quality-price" type economic efficiency function:

$$\theta_i = \frac{P_i^\wedge}{P_i},$$  \hfill (7)

where:

$P$ – production cost of i-th sample.

Note that the type criterion $\theta$ is monotonically related to the $G$ type criterion, but it is slightly more variable, sensitive to changes in various tactical and technical characteristics (TTCh), which makes it more convenient for the products in-depth technical and economic analysis.

A samples technical and economic analysis very important case is the sample with itself unary comparison situation without changes and with changes in various TTCh. At the same time, it is very often possible to form a function for a product assessing the consumer utility, which is convenient for decisions made feasibility study:

$$P_i^\wedge = P_i^\wedge(x_1, x_2, \ldots, x_i, \ldots, x_n),$$  \hfill (8)

where:

$x_i$ - i-th characteristics (TTCh) of the product.

If we have from the statistics of technical and economic analysis data similar functions for the price indicator (production cost), then it is quite possible to search for optimal solutions when creating or modernizing a product according to the criterion:

$$\theta_i = \max_{x} \frac{P_i(x)}{P(x)},$$  \hfill (9)

where:

$X$ is the sample TTCh vector.

The value of the marginal total costs for a sample life cycle in the general case can be determined by the formula:

$$E_{lip} = P_i^\wedge + I_{opt} + \sum_{i=1}^{T} P_{s_i} - P_{\mu},$$  \hfill (10)

where:
\( I_{opq} \) – capital investment in operation according to \( i-th \) sample;
\( T_{s_i} \) - service life of \( i-th \) sample;
\( P_{S_{t_i}} \) - costs of \( i-th \) sample in \( t-th \) service year;
\( P_{r_{fa}} \) - the sample residual value (taking into account its sale, disposal costs possibility).

The costs in formula (10) can be calculated with or without reduction by the time factor (i.e. with and without discounting). A more accurate estimate can be given by the calculation with reduction by the time factor.

3. Research results
Thus, the compliance degree main results with the requirements and the product life cycle cost when performing tasks as intended should be the following:

- \( G \) criteria values on one or multiple tasks;
- the limit price indicator values for a given comparison base for one or multiple tasks;
- criteria values on one or multiple tasks;
- samples limit prices functions, defined on their multiple TTCh, concerning a given task or to their set;
- the type functions \( \theta \), defined on sets of TTCh samples;
- the total marginal costs (allocations) indicators for the product life cycle, determined discretely or as a samples performance characteristics function.

4. Conclusions
The author recommends assessing the compliance degree with the requirements and achieving its costs at the product life cycle main stages in the following sequence:

- bringing initial data on analogues and evaluated samples;
- data on products (including analogues) preliminary analysis for adaptation to the task-specific conditions;
- calculating the time it takes to complete a task’ cycle;
- the effects calculating (clarification) in the task performance;
- calculating the task full costs;
- indicators calculation based on the "efficiency-cost" criterion»;
- conducting (if necessary) factor analysis of the impact on the parameters' variations limit price level, products TTCh, conditions for completing the task.

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