# CONTINUITY IN THE DESIGN OF A COMPLEX OF TECHNICAL MEANS

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## ABSTRACT

*The article examines approaches to design of a new complex of technical means of a control system. An admissible measure of continuity in creation of parts using previously adopted model solution is described. The article shows systemacity of optimal cost characteristics of products and the conditions of project development, focused on proven processes, operations, quality vectors and operational parameters.*

## ENGLISH SUMMARY

**Background.** *When designing a new complex of technical means (hereinafter-CTM) of a control system it is very important to efficiently and cost-effectively use already made decisions, and previously created designs. If for each constantly required construction designers will be forced to make only an original decision, then it will be impossible to talk about standardization and unification of parts, elements, and CTM themselves. Moreover, the rejection of already proven solutions entails additional costs due to the production of new parts and elements, which certainly leads to unnecessary overruns of cost and time, and in some cases, delays in issuing new products in a given period of time. Therefore, when designing CTM a designer seeks to use solutions, proven by practices and exploitation, as fully and economically as possible.*

*However, the desire to maximize continuity also is fraught with significant failures, as in this case, the conservative way of thinking does not allow a designer often to look for the most effective solutions and all turns into a quasi-economy. If such factors are projected and compiled, then inevitably there is a problem of dialectical reconciliation of conflicting trends, which are difficult for control.*

*Solution of a problem on a permissible extent of continuity is to create a synthesis technique that helps to develop more targeted existing experience, its rational accumulation and classification, to identify a principal opportunity to use ready-made, but not yet obsolete solutions, to choose the best option from the arsenal already available, to identify parts and elements of a construction that require original development.*

**Objective.** *The objective of the authors is to investigate continuity issue in the design process of a complex of technical means.*

**Methods.** *The authors use analysis, description, comparison and modeling, method of optimal cost characteristics.*

**Results.** *A method of optimal cost characteristics, as follows from our research, allows us to give an answer to these questions.*

*For example, we consider a system of these characteristics of a conditionally taken product (see Pic. 1).*

*Let the aim of a designer be a synthesis of an optimal structure with technical parameters determined by a vector $X^{(0)}$, to which corresponds some representative point with the abscissa, which is equal to $X^{(0)}$. We put this point on the cost characteristics of CTM. As it can be seen from Pic. 1, at the top level a point $X^{(0)}$ lies beyond a point $x_{max}$ – last one on the optimal characteristic of a zero level. This means that on the basis of existing structures of parts and elements it is impossible to synthesize CTM with a technical parameter equal to a given value of $X^{(0)}$. We will try using a system of optimal cost characteristics to determine a cause, limiting a possibility of using old solutions for the synthesis of CTM with a technical parameter $X^{(0)}$.*

*We take on the characteristics of a top-level a point with a technical parameter $x_{max}$. Points $x_1^{(1)}$, $x_2^{(1)}$, $(x_3^{(1)})_{max}$ correspond to it as for the characteristics of parts of the first level. In Pic.1 for construction of an optimal system with a parameter $x_{max}$ a point $(x_3^{(1)})_{max}$ is used, which corresponds to a limit value of a parameter $x_{(3)}^{(1)}$, whereas limit values of parameters $x_1^1$ and $x_2^1$ have not been yet used. This means that a barrier for the synthesis of CTM with a technical parameter $x^0$ is a part 3. Capabilities of structure of parts 1 and 2 have not yet been exhausted. However, this decision may be incomplete. For specification we should continue with the analysis of characteristics and go down to lower levels.*

*In this case it turns out that the reason that prevents the solution of a problem is a part 31, for which all possible resources have been exhausted, as on its characteristics when constructing a point $(x_3^{(1)})_{max}$ an extreme point $(x_{31}^{(1)})_{max}$ was used. Continuing to go down the system of cost characteristics, it is possible to determine a part of the lowest level, which prevents the creation of a given system. Obtained evidence that a selected part is a cause preventing the creation of an optimal CTM with a given value of a technical parameter is necessary, but again, insufficient. It is very likely that there are several reasons for impossibility of synthesis of an optimal system. Synthesis of a system with a parameter $x^0$ may also be hindered by the absence of capabilities of another part of a lower level – for example, part 13. It is easy to check this.*

*To investigate the cause we will extrapolate characteristic of a part 31 (dashed line) and will complete the cost characteristics of the upper levels. If due to additional points of the characteristics of a part 31 we will manage to complete characteristics of a zero level to a point $X^{(0)}$, we can state that the only reason that excludes the possibility of constructing CTM with parameter $x^0$, is the lack of a part 31 with a sufficiently high value of the parameter $x_{31}$. If we fail to build up characteristics of CTM to the point $x^0$ due to extrapolation of characteristics of a part 31, the reason probably lies in the fact that some other part of a system does not have sufficient reserves.*

*Consistently completing the characteristics of CTM (level 0) and observing the characteristics of all parts on which representative points reach extreme positions, it is possible to determine parts and elements, the parameters of which have to be improved to ensure a desired effect – to get CTM with technical parameters equal to the values of $x_1^0$.*

*Setting a way and a possible measure of additional improving of the parts of a system, it is reasonable to set a crucial question: whether defective parts should be improved to reach a set value of a parameter, or we need to abandon old solutions and make a new decision, radically differing from the existing ones?*

*The cost of a product, whether CTM or its component parts, other than the cost of completing elements necessarily includes a « fictitious node» of own costs, which characterizes the cost of assets and labor directly related to manufacturing of a product. Their inclusion in a morphological structure of CTM will allow in the design process to optimize not only a construction but also a technological process. In fact, a process of production of elements and parts of the complex is reflected in the process charts. Factors that are registered in a complete set of process charts can also be represented in the form of a hierarchical structure for which according to already*

*described algorithms a designer is able to make the best cost characteristics.*

*They are built similar to the rules of construction of a system of optimal cost characteristics of a design.*

*At the lowest level, initial operations are considered. For each of them we indicate as elements labor costs and type of equipment on which the operation is carried out. For each type of equipment a possible technological effect is indicated – via one or several parameters (similar to the vector of design parameters) and cost, reduced to a unit of maintenance.*

*Definition. Vector of technological efficiency is a set of parameters characterizing the quality of a technological process.*

*Definition. Vector of technological process quality is called (τ'+1)-dimensional, containing τ'-dimensional vector of technological efficiency and (τ'+1) parameter – a value of expenditures required to achieve a desired effect on the equipment.*

*With the help of the vector of technological process quality we characterize elementary operations. A set of technological operations, ensuring production of a single part or component can also be characterized by the vector of technological process quality of a corresponding part.*

*It is easy to see a complete analogy of the vector of technological process quality and vector of design parameters quality.*

*Construction of τ'-dimensional cost characteristics of a technological process can be carried out again in the (τ'+1)-dimensional space of its quality.*

*If there are multiple options for technological processes, as it has been done for several possible structures of parts, it is necessary to construct generalized cost characteristics and using them to choose economically feasible option of a technological operation at a lower level or technological process at the highest level.*

*Similarly we will take into account functional qualities of production of parts and CTM.*

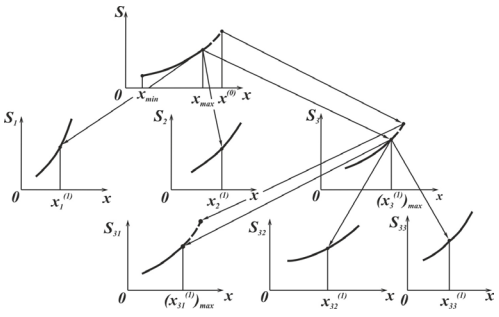
*We introduce a concept of functional qualities vector of parts or CTM.*

*Definition. Functional qualities vector of a part or CTM is a set of parameters characterizing operational features, which are demonstrated by equipment.*

*Definition. Operation quality vector of a part or CTM is a (τ»+1) -dimensional vector containing τ»-dimensional vector of operational properties and (τ»+1) parameter – the amount of costs, ensuring normal operation of a part or CTM.*

*A cost component of operation quality vector of a part or CTM includes depreciation costs, and the costs of repair and restoration of products that are listed to a unit of maintenance. When designing a single part it is assumed that CTM is designed for an adequate maintenance.*

*For each part, operating costs can be presented as a stand-alone, and its structure subnode contains «exploitation». As it can be seen from the definition of*



***Pic. 1. System of optimal cost characteristics (identification of a part, which prevents a further improvement of a parameter $X^{(0)}$).***

*vectors of quality of design parameters, technological efficiency and operational efficiency, there is a certain analogy between them which lies in the fact that any of these vectors contains a number of design, technological or operational parameters and one economic parameter – cost. This analogy enables to introduce a single vector of quality of parts and CTM as a whole. The dimension of this vector:*

$$m+1= m' + m'' + m'''+ 1,$$

*where m' – the dimension of design parameters vector;*

*τ'' – the dimension of technological efficiency vector of production;*

*τ''' – the dimension of performance properties vector.*

*In view of additivity of expenditures a cost (τ+1) component of the vector of quality:*

$$S=S'+S''+S''',$$

*where S' – the value given to a unit of maintenance that characterizes design parameters of a part (mostly the cost of incoming components and parts);*

*S'' – the cost of a technological process for the layout of a part from elements and incoming units (own expense), reduced to a unit of maintenance;*

*S'''– the total operating expenses (direct operating costs, depreciation, repairs) provided to a unit of maintenance.*

*Definition. Complete vector of quality of an element, products or CTM is called a (τ + 1) -dimensional vector whose τ components characterize technical, technological and operational parameters of an object, and (τ+1) component is cost, reduced to a unit of maintenance.*

**Conclusion.** *We note that in the presence of cost characteristics of all parts in the system on a project stage of cost characteristics of technological processes and operating costs, we get an opportunity through the synthesis of CTM to take into account at the same time its design, technological and operational parameters. This greatly enhances the potential of a proposed method and creates conditions for continuity and complex design of a product.*

*Keywords: technical means, modeling, project, parameters, technology, continuity, cost, design, parts, product, complex, quality vector*

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