Journal of Management & Technology
e-ISSN: 2177-6652

SYNTHESIS OF THE STRUCTURE OF AN AUTOMATED POWER MANAGEMENT SYSTEM IN AN INDUSTRIAL ENTERPRISE

SÍNTESE DA ESTRUTURA DE UM SISTEMA AUTOMATIZADO DE GESTÃO DE ENERGIA EM UMA EMPRESA INDUSTRIAL

SÍNTESIS DE LA ESTRUCTURA DE UN SISTEMA AUTOMATIZADO DE GESTIÓN DE ENERGÍA EN UNA EMPRESA INDUSTRIAL

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Scientific Editor: José Edson Lara
Organization Scientific Committee
Double Blind Review by SEER/OJS
Received on 03/02/2022
Approved on 07/12/2022

ABSTRACT

Currently, the design of complex systems is carried out by developing one of the possible options, which largely depends on the individual abilities and experience of developers. The implementation of this option in the future will be determined by the persistence and organizational abilities of the project authors, often regardless of the quality of the chosen option. The theory of building complex information systems, which include automated control systems, and the features of choosing the structure of such systems have not been sufficiently developed to date. At the same time, there is an opinion that if the author has not considered at least three alternative variants of structural schemes then the possibility of choosing the most preferred solution is very small, and the less the more complex the system is. A brief analysis of the advantages and disadvantages of various methods of constructing a generalized quality indicator has shown that the resulting objective quality function, constructed taking into account the physical connections of the automated control system with other systems, united by common functioning and joint placement as part of a technical complex, is characterized by the smallest elements of subjectivity and conditionality.

Keywords: Assessing the quality of large systems operation, designing process of automated control systems, using economic criteria.

RESUMO

Atualmente, o projeto de sistemas complexos é realizado desenvolvendo uma das opções possíveis, que depende em grande parte das habilidades individuais e experiência dos desenvolvedores. A implementação desta opção no futuro será determinada pela persistência e capacidade organizacional dos autores do projeto, muitas vezes independentemente da qualidade da opção escolhida. A teoria da construção de sistemas de informação complexos, que incluem sistemas de controle automatizados, e as características de escolha da estrutura de tais sistemas não foram suficientemente desenvolvidas até o momento. Ao mesmo tempo, há uma opinião de que, se o autor não considerou pelo menos três variantes alternativas de esquemas estruturais, a possibilidade de escolher a solução mais preferida é muito pequena e, quanto menor, mais complexo é o sistema. Uma breve análise das vantagens e desvantagens de vários métodos de construção de um indicador de qualidade generalizado mostrou que a função de qualidade objetiva resultante, construída levando em consideração as conexões físicas do sistema de controle automatizado com outros sistemas, unidos pelo funcionamento comum e colocação conjunta como parte de um complexo técnico, caracteriza-se pelos menores elementos de subjetividade e condicionalidade.

Palavras-chave: Avaliação da qualidade de operação de grandes sistemas, processo de projeto de sistemas de controle automatizados, usando critérios econômicos.

RESUMEN

Actualmente, el diseño de sistemas complejos se lleva a cabo mediante el desarrollo de una de las opciones posibles, que depende en gran medida de las habilidades individuales y la experiencia de los desarrolladores. La implementación de esta opción en el futuro estará determinada por la persistencia y la capacidad organizativa de los autores del proyecto, a menudo independientemente de la calidad de la opción elegida. La teoría de la construcción de sistemas de información complejos, que incluyen sistemas de control automatizados, y las características de elegir la estructura de dichos sistemas no se han desarrollado lo suficiente hasta la fecha. Al mismo tiempo, existe la opinión de que si el autor no ha considerado al menos tres variantes alternativas de esquemas estructurales, la posibilidad de elegir la solución preferida es muy pequeña, y menor cuanto más complejo es el sistema. Un breve análisis de las ventajas y desventajas de varios métodos para construir un indicador de calidad generalizado ha demostrado que la función de calidad objetiva resultante, construida teniendo en cuenta las conexiones físicas del sistema de control automatizado con otros sistemas, unidos por el funcionamiento común y la ubicación conjunta como parte de un complejo técnico, se caracteriza por los elementos más pequeños de subjetividad y condicionalidad.

Palabras clave: Evaluación de la calidad de operación de grandes sistemas, proceso de diseño de sistemas de control automatizado, utilizando criterios económicos.

1. INTRODUCTION

Due to the specifics and complexity, the designing process of automated control systems (ACS) has not been formalized to a large extent until recently. The existing GOST standards and methodological materials define organizational issues and regulate the composition and content of the project documentation, but do not contain recommendations and instructions that reveal the essence of creating an ACS.

Structure synthesis generally refers to determining the composition and interaction of individual subsystems. When solving the problem of structure synthesis, the principles of organization's management, the organizational hierarchy of the system, the structure of information transmission and processing should also be determined. These tasks together form a complex problem. Currently, a formalized solution has been obtained only for several particular problems of optimizing the structure of the ACS of the enterprise (Grigorieva, 2008).

The complexity of the system in terms of choosing its structure is usually associated with a large number of options for its organization. The number of possible options depends on the variety of functions performed, the number of system components, possible ways to implement these components, and the variety of information links between subsystems.

2. METHODS

The ACS, belonging to the category of complex systems, are characterized by a variety of information inputs and outputs. The information received at the ACS input can be of three types. It can be preset – consisting of the requirements of regulatory documents, the fleet of electrical equipment, the structure of the power service, etc.; random – consisting of operational information about the failure of electrical equipment, changes in the parameters of the technological process, etc.; and information, received at a certain frequency, for example, the results of the work of individual teams to carry out operational activities.

Let us denote the set of ACS inputs as $\vec{X}$, while $\vec{X}$ should be considered as a vector whose dimension is equal to the number of inputs, and denote the coordinate X_i as a parameter of the incoming signal. The ways of setting the ACS outputs in principle do not differ from setting the inputs. We can consider the time of troubleshooting, the work assignment form, the complexity of performing individual operations, cost indicators, etc. as the ACS output characteristics. Let us denote the set of output characteristics $\vec{K}$ and call it the output trajectory.

In the theory of complex systems, the dependence of output characteristics on input indicators is called the system functioning law

$$\vec{K} = F(\vec{X}) \qquad (1)$$

The functioning law can be given in the form of a function, functional, logical conditions, tabular form, etc.

The power service ACS should be attributed to the class of information and control systems. A distinctive feature of such systems is the fact that the implementation of the system functioning law $\vec{K} = F(\vec{X})$ results in the development of information, used to manage the object, for example, to carry out operational activities. Through the operator, this information affects the work of departments.

The first stage in the synthesis of complex technical system structures, carried out at the initial stages of development (pre-design and preliminary design), is the decomposition of the concerned system into subsystems.

The function $\vec{K} = F(\vec{X})$ defines the control law in the sense that for each parameter value X it is uniquely possible to determine the value of the characteristics K. However, the process of finding such a match, i.e. the process of processing input information into output information, can be organized in different ways.

Let's consider the most typical case of the energy service ACS of the enterprise. Thus, transformation (1) can be replaced by two equivalent transformations:

$$K_i^{(1)} = F_i^{(1)}(X_i); \; X_i \subset X; \bigcup X_i = X, i = 1,2,\dots,n, \qquad (2)$$

$$K = F_1(K^{(1)}),\; K^{(1)} = \left[K_1^{(1)},\dots,K_n^{(1)}\right]. \qquad (3)$$

The transformation (1) is carried out in two stages. At the first stage, a transformation $F_i^{(1)}$ is performed over a subset of input parameters $X_i \subset X$, and an intermediate result $K_i^{(1)}$ is obtained. The received information $K_i^{(1)}$ transforms F_i, and as a result, we get the output information (K) of the system. The described approach is implemented, for example, when drawing up a schedule of planned works of the energy service, where first we receive enlarged Tables, and then we build the corresponding schedule.

To ensure that transformations (2) and (3) are equivalent to transformation (1), the relation must be fulfilled:

$$F = F_1\left[F_1^{(1)}, F_2^{(1)},\dots,F_{n_1}^{(1)}\right]. \qquad (4)$$

Transformations $F_1^{(1)}$ and F_1 can be carried out by different subsystems of the system. Thus, relation (4) reflects the structure of the functional division of the system into subsystems and the way of implementing the general law of the system functioning.

The sequence of intermediate transformations $\left[F_1^{(1)}, F_2^{(1)},\dots,F_{n_1}^{(1)}\right]$ is called the set of partial operators of the first stage of the partition of the function F and is denoted as $R^{(1)}$.

$$R^{(1)} = \left[F_1^{(1)}, F_2^{(1)},\dots,F_{n_1}^{(1)}\right] \qquad (5)$$

Thus, the operator F_1 is the operator of the first stage of the partition.

In turn, the operator of the first stage of partition F_1 can be implemented in several stages

$$F_1 = F_2\left[F_1^{(2)}\left(R_1^{(1)}\right), F_2^{(2)}\left(R_1^{(1)}\right), \dots, F_{n_2}^{(2)}\left(R_{n_2}^{(1)}\right)\right] \qquad (6)$$

where $R_i^{(1)} \subset R^{(1)}$ is a subset of partial operators of the second stage;

$\left[F_1^{(2)}, F_2^{(2)}, \dots, F_{n_2}^{(2)}\right] = R^{(2)}$ is the set of partial operators of the second stage;

F_2 is the transformation operator of the second stage of the partition of the function F.

In the general case, we can write

$$F_{v-1} = F_v\left[R^{(v)}\right]. \qquad (7)$$

Thus,

$$R^{(v)} = \left[F_1^{(v)} R_1^{(v-1)}, F_2^{(v)} R_2^{(v-1)}, \dots, F_{n_v}^{(v)} R_{n_v}^{(v-1)}\right] \qquad (8)$$

where $R^{(v)}$ is the set of partial operators of the *v*-th stage of the partition of the transformation function F;

F_v is the transformation operator of the v -th stage of the partition of the function F.

Let us us now call the sequence of partial operators $R^{(v)}$ the structure of the control law and denote by S

$$S = \left[R^{(1)}, R^{(2)}, \dots, R^{(m)}\right]. \qquad (9)$$

All sequences of the form (9), by which the general control law of the system $U = [X, K, F]$ can be represented, determine the set of possible ACS structures that have this control law.

Given sequences of the form (7) and (8), the ACS structure can be represented as a set of partial operators of all stages of the partition

$$S = \left[F_1^{(1)}(X_1), \dots, F_{n_1}^{(1)}\left(X_{n_1}\right), F_1^{(2)}\left(R_1^{(1)}\right), \dots, F_{n_2}^{(2)}\left(R_{n_2}^{(1)}\right), \dots, F_{n_m}^{(m)}\left(R_{n_m}^{(m-1)}\right)\right] \qquad (10)$$

where; $F_i^{(j)}$; $i = 1,2,\dots,n_m$; $j = 1,2,\dots,m$ is the *j*-th partial operator of the *i*-th stage of the partition.

A subsystem $A_i^{(j)}$, implementing the operator can be assigned to each partial operator $F_i^{(j)}$. Thus, by specifying n stages of partitioning, we thereby define a set of subsystems that the ACS should consist of. Thus, *j* operators of each of the subsystems specify possible options for the technical implementation of each of the subsystems.

The operator $F_i^{(j)}$ of the subsystem $A_i^{(j)}$ determines the functioning law of this subsystem

$$K_i^j = F_i^j\left(X_i^{j-1}\right), \qquad (11)$$

where $X_i^{(j-1)}$ are the inputs of the subsystem $A_i^{(j)}$, determined by the outputs of the subsystem of the (i – 1)-th stage of the partition according to a subset $R_i^{(j-1)} \subset R^{(j-1)}$ of partial operators of the (j – 1)-th stage of the partition of the transformation function F .

If the partition operators $F_i^{(j)}$ of the general transformation function F of the system are performed by separate subsystems of the system, then the set of partial operators also defines the system’s structure, which can be written as

$$S = \left[X_i^{(j-1)}, F_i^j, K_i^j\right]. \qquad (12)$$

The partition of the transformation function F into partial operators can be carried out in various ways and, consequently, the same control law can be implemented using a different structure S . Therefore, we can talk about a certain set of structures U , generated by the control law $\vec{K}(t) = F(\vec{X})$. In the general case, the set of structures U can be infinite.

The structure of the information control system may be different. The following types of structures are given in the technical literature: decentralized, centralized, and dispersed structures.

The conducted analysis of the information processing process in the ACS EES (automated control systems of electrical engineering service) has shown that several tasks are characterized by a multi-stage hierarchical process of obtaining output results. Thus, the transformation of information when drawing technical services and ongoing repairs schedule is carried out in several stages. Initially, the nomenclature of equipment is set for a given list of objects, then the complexity of operational measures is determined, enlarged Tables are compiled, and then the schedule is drawn. There are also parallel links between subsystems. For example, when performing operational activities, it is necessary to refer to the electrical equipment file and the reserve fund file and enter their results into the relevant documents at the end of the work.

3. RESULTS

The research results show that it is advisable to use a hierarchical structure with sequential and parallel connections of subsystems in the ACS of the energy service. Such structures usually have great flexibility and survivability.

The formulation of the task of synthesizing the structure of the ACS can be specified in the form of the following operations:

- forming a block of initial information;
- decomposing the system into elements;
- developing a method for forming possible variants of structures;
- substantiating the system of partial quality indicators and the resulting objective function;
- developing a method for searching for the optimal version of the ACS in a multidimensional discrete space of alternatives based on a generalized quality indicator.

From a scientific perspective, a serious problem among these tasks is developing a formalized method for forming variants of structures. Until recently, this task in most cases is solved on an intuitive level considering a limited number of options. With this approach, the loss of the optimal solution is not excluded.

Among the available methodological approaches to structural synthesis, the morphological method of structure synthesis is of considerable interest (Khorolsky, Taranov, 2001). This method is based on the aggregate principle of building complex systems, while the entire system is divided into several functionally complete blocks (elements), and the process of forming variants represents a sequence of formalized procedures, whose machine implementation is associated with processing the initial information. Predicate calculus is used as the mathematical basis of the morphological synthesis method, which allows structural synthesis to be presented as a deductive axiomatic theory with a standard formalization and a unified synthesis process in structure. To exclude a complete enumeration, it is proposed to combine the process of forming variants of structures with simultaneous verification of the joint applicability of elements and the fulfillment of external conditions.

The processing of information is based on the use of well-known rules of logical inference (Stoll, 1968): the rules of equivalent transformations and substitution, the distributive law of transformations, etc. Logical formulas act as the final product of information processing and are a universal means of formalizing synthesis procedures. Thus, it must be remembered that individual synthesis tasks, such as, for example, the composition of a structure from individual functional elements, cannot be solved at all without involving the apparatus of mathematical logic.

Using the main theoretical provisions of the method under consideration, we formulate the problem of structural synthesis in the following form:

1. Considering one of the possible variants of a set of external factors of X_g;

2. A set $Z = \{Z_1, Z_2, ..., Z_i\}$ of ACS elements is set. Each of the active elements A_r, $r = 1,2,...,R$, can have q variants of technical implementation, i.e. $A_r = \{A_{r1}, A_{r2}, ..., A_{rq}\}$.

3. The vector of properties $\overrightarrow{K}(Z_i) = < K_1(Z_i), K_2(Z_i), ..., K_V(Z_i) >$., tested in structural synthesis is known, while for the synthesis element $K_v(Z_i)$ it is specified in the form $K_v(A_{rq})$ 4. Sequential structures $A^2 = \{A_1^1, A_2^1, ..., A_R^1\}$ can be formed from the ACS elements, where A^1 is a set of possible variants of elements.

5. Boundary conditions of $K_v(*)$, $\beta_1 \Leftrightarrow \overline{Z}_i \vee Z_0$, type are set.

It is required to find solutions $Y = \{Y_1, Y_2, ..., Y_F\}$, where $Y_\varphi = \{A_1^1, A_2^1, ..., A_R^1\}$ which would consist of jointly applicable subsystems, satisfy the specified constraints, and meet the totality of external conditions for the functioning of the ACS.

To solve the problem of structural synthesis, we consider several successive sub-steps:

P_1 – checking restrictions on the parameters of elements;

P_2 – forming a set of tuples of acceptable variants of aggregates;

P_3 – checking restrictions on the joint applicability of structural scheme elements;

P_4 – assessing the conformity of the obtained ACS options to external conditions;

P_5 – obtaining a solution to the structural synthesis stage in the form of a set of functionally necessary structures.

To avoid a complete enumeration, it is possible to combine sub-steps P_2, P_3, and P_4 into a single process. Thus, each time, when a new element is inserted into the composition of the formed tuple, it is necessary to check the conditions of its joint applicability with other elements and the compliance of the resulting sets with the external conditions of the ACS operation.

Initially, we solve the problem of determining the set of all valid elements. On the set Z of all elements, possible for using in the ACS, considered taking into account a given set of external conditions X_g, a subset Z^1 of acceptable elements is identified. To this end, for each element A_r, the "property" is first checked to satisfy the v -th boundary condition:

$$\mathrm{p}_{\mathrm{Arqv}}(\mathrm{A}_{\mathrm{rq}}) = \begin{cases} 1, \text{ if } \mathrm{K}_{\mathrm{v}}(\mathrm{A}_{\mathrm{rq}}) \in \mathrm{K}_{\mathrm{v}}^{(*)}, \\ 0 \text{ if } \mathrm{K}_{\mathrm{v}}(\mathrm{A}_{\mathrm{rq}}) \notin \mathrm{K}_{\mathrm{v}}^{(*)}. \end{cases} \qquad (13)$$

Belonging to the desired class of synthesis tools is described by the following logical expression:

$$p^1_{Arq}(A_{rq}) \Leftrightarrow \bigwedge_{v=1,2,\ldots,N} p_{Arqv}(A_{rq}). \qquad (14)$$

After that, tuples are formed. From the acceptable variants of elements, tuples $A^1 = \{A^1_1, A^1_2, \ldots, A^1_R\}$.can be formed. Thus, the specific variant A_{rq} of each element of the r-th type, which is a component of this tuples, is selected in the set A^1_r. The adopted indexing excludes the need to introduce additional conditions for the non-permutation of the tuple components.

Since for each set of external conditions X_g, the set A^1 of all possible variants of elements is considered, then $A^1 \bigcup\limits_{r \in R} A^1_R \, u \, \bigcap A^1_R = \varnothing$. Taking this into account, the multitude of resulting sets of elements is defined as follows:

$$A^1_1 \times A^1_2 \times \ldots \times A^1_R \equiv \prod_{r=1}^{R} A^1_r. \qquad (15)$$

At a small number of elements under consideration, it is quite simple to evaluate all the solutions obtained from the standpoint of satisfying the imposed restrictions and thereby obtain the desired set of functionally necessary structures. In this case, the Θ predicates, characterizing the fulfillment of the conditions of joint applicability, are described as follows:

$$p^3_{A\beta}(A^2) \Leftrightarrow \beta, \qquad (16)$$

where $\beta = 1, 2, ..., \Theta$ are statements, which are the conditions of common applicability of various elements of technical performance, and representing the disjunction of the conjunction of simple statements like "the application of device A_{rq}", referred to as a_{rq}, and denial of these statements, having the meaning of "non-application of the device A_{rq}", denoted as $\overline{a}_{rq}$, of predicates, describing the external conditions, of which each is denoted as:

$$p^4_{Ag}(A^3) \Leftrightarrow X_g, \quad g = 1, 2, \ldots, G \qquad (17)$$

and characterizes the property of the considered set to meet the *g*-th partial condition.

Taking into account the above, the process of obtaining the functionally necessary structures of the ACS will be described by the following logical expression:

$$((\forall A^2)p^2_A(A^2) \underset{\beta=1,2,\ldots,\Theta}{\wedge} p^3_{A\beta}(A^2) \underset{g=1,2,\ldots,G}{\wedge} p^4_{Ag}(A^3)) \Leftrightarrow (\forall A^4)p^4_A(A^4). \qquad (18)$$

The main disadvantages of the considered approach consist in the need to analyze a significant number of structures in the presence of several variants of elements. Thus, assuming a very real situation $A^1_1 = 3,\ A^1_2 = 8,\ A^1_3 = 4,\ A^1_4 = 4,\ A^1_1 = 3,\ A^1_2 = 8,\ A^1_3 = 4,\ A^1_4 = 4,$ in the synthesis of ACS, we get the number of tuples equal to 384. It is also possible that structurally redundant systems are also formed when all types of elements are included in each set.

To reduce the amount of calculation and eliminate redundancy, a sequential algorithm has been developed that combines the tuple formation procedure with checking restrictions on joint applicability and fulfillment of external conditions (Khorolsky, Taranov, 2001).

The main advantages of the proposed approach are:

- reducing time spent on obtaining the required set of functionally necessary structures;
- the simplicity of machine implementation, since when forming tuples, it is necessary to consider only the restrictions on a specific subsystem, while not representing the rest of the prohibitions;
- the convenience of making changes to the source information block, since the parameters for each new unit are entered once together with the terms of its use;

- excluding the possibility of obtaining redundant structures, since compliance with external factors is checked during the composition of tuples.

The process of designing the ACS at the initial stages consists in developing a set of functionally necessary structures and comparing them according to one (generalized) or several evaluation criteria. With this approach, the main attention is paid to the purpose of creating a system and the choice of quantitative evaluation criteria. Automated systems are characterized by the efficiency of their operation, reflecting the degree of achievement of the set goal. The purpose of creating the ACS may be increasing the productivity of electricians, reducing the accident rate of the electrical equipment fleet, increasing the staff's performance efficiency, reducing operating costs, etc. Certain funds and time are needed to create the ACS, and, as a rule, large funds and time are required for a more efficient operation of the designed system.

As a rule, the success of optimization depends on the correct choice of evaluation criteria. The presence of a large number of optimality principles, known in the technical literature, poses the problem of choosing approaches that best meet the specifics of the search for the optimal version of the ACS. This task is solved at the conceptual level.

To date, two approaches to the selection of optimality criteria for complex technical systems have become the most widespread (Khorolsky, Taranov, 2001; Wentzel, 2001; Khorolsky et al., 2008). These are using one of the considered indicators, taken as the main characteristic, and constructing a generalized indicator.

The method, based on the translation of all partial quality indicators, except one, into the category of restrictions, is the simplest. In this case, one indicator, which subjectively seems to be the most important, is selected out of the set of output parameters of the system. At the same time, restrictions are imposed on the remaining indicators. Mathematically, the problem reduces to finding a conditional extremum. Characteristics, reflecting rate, accuracy, cost, etc. can be selected in this situation as the main criterion for assessing the quality of the ACS. In this formulation, the problem of selecting the optimal solution is formed as a mathematical programming problem:

$$\max_{Y_\phi \in D_Y}(\min)\left[k_i(Y_\phi)\right], \text{ at } k_\text{э}(Y_\phi) \geq k_\text{э}^*,\ k_c(Y_\phi) \leq k_c^* \quad (19)$$

where $k_\text{э}^*, k_c^*$ is a set of performance or cost indicators that are subject to restrictions.

The limitedness of the approach under consideration is obvious since we avoid vector synthesis and there are no sufficient grounds for choosing one of the characteristics as the resulting objective function and transferring the remaining indicators to the category of restrictions.

Given the above, in recent years, the opinion about the need for a multi-criteria approach to assessing the quality of complex technical systems has become increasingly widespread.

The most rigorous and accurate expression of the quality of the ACS is obtaining a generalized indicator through the physical dependencies of the output characteristics within the system under consideration and a complicated technical complex (of energy services and enterprise in general) as a large system that includes the ACS. In this case, a generalized quality indicator can be formulated, which we will call objective.

Thus, according to the principle of unambiguity, the resulting objective function, as an optimality criterion, should be applied in the form of a single generalized indicator that includes all the output characteristics under consideration.

The generalized quality indicator of the ACS can be represented by a function of *m* variables in (m+1) dimensional space

$$k_{m+1} = f_k(k_1, k_2, \ldots, k_m) = f_k(\vec{K}) \qquad (20)$$

Since the indicator k_{m+1} is a scalar quantity, rather than a vector, its introduction essentially means a transition from a vector problem to a scalar problem of comparing alternatives. Such scalarization allows not only simplifying the search for the optimal solution but also comparing the ACS options, which, according to the Pareto criterion, turn out to be fundamentally incomparable. Thus, by introducing a generalized quality indicator, the possibility of incomparable solutions is excluded.

The generalized quality indicator is expressed in terms of components using a finite number of certain elementary operations.

In some cases, the resulting objective function is constructed using additive or multiplicative transformations over the selected system of output characteristics. When using additive transformations, we have:

$$k_{m+1} = d_1 k_1 * + d_2 k_2 * + \ldots + d_v k_v * + \ldots + d_m k_m * \quad (21)$$

where $k_v * = k_v / k_v^n$,

k_v^n is the reference value of the indicator taken as a measurement unit;

d_m are weight coefficients, characterizing the relative importance of each of the indicators.

When using multiplicative transformations, we get:

$$k_{m+1} = \prod_{v=1}^{m} (k_v^*)^{\alpha_v} \quad (22)$$

where α_v is an indicator of importance.

The main disadvantage of the considered group of generalized quality indicators is the possibility of mutual compensation of heterogeneous components. Thus, additive convolution has the simplest mathematical structure that facilitates the solution of the problem; however, this causes the problem of determining the $d_1, d_2, \ldots d_m$ coefficients.

4. CONCLUSION

Of the considered conditional criteria, the simplest and most convenient for use in engineering practice is a multi-purpose indicator representing a linear convolution of the output characteristics under consideration.

Thus, if the requirement of the possibility of setting the task of finding an unconditional criterion is considered a mandatory property of the generalized criterion, then it can be stated that for most systems, only economic criteria have this property. These criteria have become widely used to evaluate complex management systems also because the very economic indicators have become one of the most important parameters of these systems.

The expediency of using economic criteria to assess the quality of functioning of large systems is beyond doubt, however, there is currently no consensus on what kind of economic criteria should be used as an optimality criterion.

In the days of the planned economy, it was proposed to use discounted costs as a criterion of economic feasibility. Along with this indicator, the so-called full cost criterion has become widespread among information systems specialists. It seems to us that in the context of market relations, it is advisable to use indicators, such as net profit or net present value (NPV) to assess the effectiveness of ACS, which characterizes the excess of total cash receipts over total costs for a given project, taking into account the uneven effects (costs, results) related to different points in time.

For the project to be recognized as effective, the NPV must be positive. In a comparative assessment, preference should be given to a project with a higher NPV.

The basis for calculating the NPV is the cash flow plan, which is built by analyzing cash inflows and outflows.

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