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STRUCTURE OF ORGANIZATION OF MANUFACTURING CONTROL MECHANISM SYNTHESIS

The paper considers the set-theoretical approach to the synthesis of information processing and manufacturing control system, that allows with the utmost generality to take an approach to the problem of complex system description.

Key words: *hierarchical system, convex sets, subsets, fixed point, controllability, enterprise management, structure synthesis, administration.*

Introduction

In connection with the transition to economic methods of manufacturing control, there had been set a new promising phase of complex automation of production through the creation and usage of information processing systems and management (IPSM), in which the mainstreams of technical progress in industry are being realized: the integration of design and sampling (DS); manufacturing systems control, improving administration on the basis of wide use of multipurpose technology equipment.

The main tasks of IPSM synthesis, as hierarchical manufacturing control systems, are consistent with the state scientific and technical program stated in the Law of Ukraine "On scientific and production activity". Therefore, the relevance of this work is obvious.

Based on the analysis of the data in the literature [1 - 4], it was revealed that at present the synthesis of IPSM is performed:

1. With the application of the approach of aggregation and decomposition [1], including sequential decomposition being performed by the system of targets, functions and tasks; aggregation (combination) of elements at the corresponding specification level to generate alternate system designs based on the chosen performance criterion.

2. By the parametrization of the initial problem in the control variable vector dimension for the detached elements, which the complex object consists of [2]. Optimality criterion of the parameterized problem is in exponential relationship with its dimension and includes factors that take into account the complexity of optimization algorithms of the various management levels.

3. Representing system as the graph of signals. He methodological solution of this task is based on the sequential extension of system structure through the connection of the complement part that imparts some features [3].

4. With the application of heuristic rules that often lead to the deadened systems [4].

General disadvantages of the known approaches are huge costs and imperfection that require further improvement and not always come to satisfactory results.

The objective of this study is to develop a strict formal method based on set-theoretical structures.

Process of synthesis of the manufacturing control structure is chosen as the object of the study.

Subject of research is apparatus and mathematical models of decision making. Methods of the theory of system analysis, synthesis and optimization of organizational structures have been uses to solve the assigned task.

Scientific novelty of research is the development of approaches and methods of automated synthesis of the structure IPSM.

The solutions of the problem is founded on set-theoretical approach, that is based on the presentation of the system as a set of elements, which structure is defined as a set of surfaces of different classes and sets pairing specified on the elements of structure and synthesis procedure specified through the set-theoretical operations on sets [4].

Main part

Information processing systems and management system (IPSM) of manufacturing structure can be presented as the collection of organization system (OS), information-management system (IMS) and executive system (ES) (fig 1).

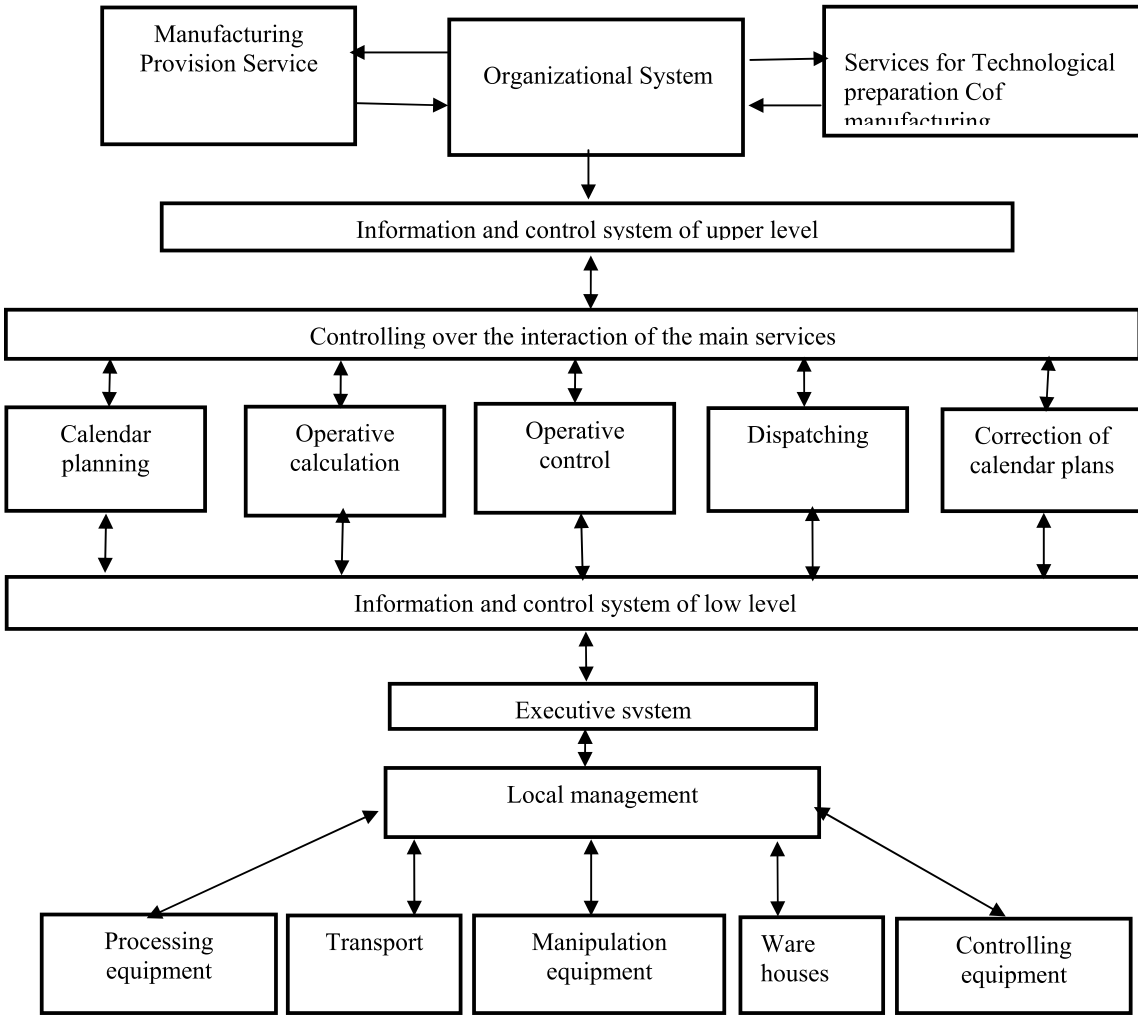

Fig. 1. Functional diagram of the organizational mechanism of controlling over industrial manufacturing

The organization system (OS) is a set of tools and methods, defining the objectives and criteria of the operation of PP on the basis of the target task and its current state. The main function of the OS is to create formal target task for IMS. Number of auxiliary functions is required for its realization: data accessing and analyzing from IMS on the status of the system, the receipt and interpretation of the target tasks from the top management levels, processing software and descriptions of technological processes routing of the automated system of technological preparation of production (ASTPP) [3] to new targets of processing and its including into IMS library and database. This organizational system is required to support working under the states of AP, which are not supposed for IMS, so it should perform the following functions: recognition of the extreme cases, the decision making in order to remove them, responses providing to various requests from the upper management levels, i.e. request querying, formalization of requests for IMS, data transfer from IMS to higher management system.

The executive system (IS) is a set of execution resources able to ensure realization of all the required operations of the target tasks set. Executive tools include all types of equipment and skilled people. Input parameters for the ES are the material flows (blanks, tools, devices), target task and information on the work-in-process.

The information-management system (IMS) is a system that provides interaction between the control elements in the process of implementing the target task in accordance with the objectives and criteria for the operation, given by the organizational system. Managed parameters are the order and term of the production of all detail-operation launching of the target task.

For the synthesis of optimal structure set-theoretical approach had been used, as it is one of the most effective, as it provides an opportunity to provide the design with the specific mathematical structures more fully, and generalized approach to the problem of describing complex systems, such as IPSM.

In doing so, we proceeded from the concept of a system *S* as a subset of the Cartesian product of a collection of sets:

$$\{V_i | i \in I\} \quad \mathrm{S} \subset \prod_{\mathrm{i}=\mathrm{I}} \mathrm{V_i} \,,$$

where I – set indices, taking into account existence of the global reaction of the system

$$R : X \times \prod_{i \in I_1} V_i \to \prod_{j \in I_2} V_j \,,$$

where $I_1 \bigcup I_2 = I$ и $I_1 \bigcap I_2 = \varnothing$;

X – some abstract set called state set.

Hierarchical n – level system U presents set of five:

$$U = (X, Z, \Omega, \varphi, \psi), \tag{1}$$

where X – set of states of the system which is Cartesian product of sets $X = \prod_{i=1}^{n} X_i$.

Control set Z and set of external influences Ω make up the set of mappings:

$$\forall z \in Z \quad Z : X \to X,$$

$$\forall \omega \in \Omega \quad \omega : X \to X.$$

And

$$Z = \prod_{i=1}^{n} Z_i \,, \ \Omega = \prod_{i=1}^{n} \Omega_i \,,$$

So that

$$z(x) = (z_1(x_1), z_2(x_2), \ldots, z_n(x_n));$$

$$\omega(x) = (\omega_1(x_1), \omega_2(x_2), \ldots, \omega_n(x_n)),$$

For all $x = (x_1, x_2, \ldots, x_n) \in X$, where $z_i \ni Z_1 : X_i \to X_i$, $\Omega_i \ni \omega_i : X_i \to X_i$.

Let us assume that sets Z_i and Ω_i contain $\wedge$ element , such that $\wedge(x) = x$, for all $x \in X_i$ and for $i = 1, 2, \ldots, n$.

Then,

$$\varphi : X \to P(X), \ \psi : X \to P(Z),$$

where $P(X)$ - set of all nonempty subsets, sets m, φ and ψ are diagonal products of

$$\varphi = \mathop{\Delta}_{i=1}^{n} \varphi_i, \ \psi = \mathop{\Delta}_{i=1}^{n} \psi_i$$

mappings

$$\varphi_i : X \to P(X_i),\ \psi_i : X \to P(Z_i),\ (i = 1,2,\ldots,n).$$

Therefore for every $x = (x_1, x_2, \ldots, x_n)$ $\varphi(x) = \prod_{i=1}^{n} \varphi_i(x)$, $\psi(x) = \prod_{i=1}^{n} \psi_i(x)$, $\varphi_i(x)$ are defined by the

values of multitask mappings

$$\varphi_{ki} : X_k \to P(X_i),\ (k = 1,2,\ldots,n), \tag{2}$$

The same as the first nonempty set in sequence

$$A_n \subseteq A_{n-1} \subseteq \ldots \subseteq A_1,$$

$$A_m = \bigcap_{k=1}^{m} \varphi_{ki}(x_k),\ (m = 1,2,\ldots,n).$$

Similarly $\psi_i(x)$ – first nonempty intersection

$$B_m = \bigcap_{k=1}^{m} \psi_{ki}(x_k)$$

In sequence

$$B_n \subseteq B_{n-1} \subseteq \ldots \subseteq B_1.$$

Therefore hierarchical system (1) can be considered as the system consisting of n - levels $(i = 1,2,\ldots,n)$

$$U_i = \left(X_i, Z_i, \Omega_i, \{\varphi_{ij}\}, \{\psi_{ij}\}_{1 \le j \le n} \right) \tag{3}$$

Let's call set X_i set of sates of the i-th level, Z_i – set of possible controls on the i-th level and Ω_i – set of external influences on the i-th level. $\varphi_{i_j}(x)$ can be interpreted as a set of the j-th level, which meet the requirements of the i-th level at the state of $x \in X_i$. In particular the set $\varphi_{i_i}(x)$ will be called a target of the i-th level, in correspondence to state x. If $\varphi_{i_j}(x) = X_j$, it means that state x of the i-th level is invariant to the states of the j-th level (absence of targeting).

Set $\psi_{i_j}(x)$ is a set of allowed controls at the j-th level determined by state x *of* U_i level. The absence of controllability limitations at j-th level from U_i level in the x state, and it's stated that $\psi_{i_j}(x) = Z_j$.

Mappings φ_i and ψ_i define priority levels (3). Actually, when defining $\varphi_i(x)$ values ($\psi_i(x)$) (accordingly $x = (x_1, x_2, \ldots, x_n)$) first of all the elements of the set $\varphi_{1i}(x_1)$ are to be considered, then $\varphi_{2i}(x_2)$ etc up to $\varphi_{ni}(x_n)$ (accordingly $\psi_{1i}(x_1)$, $\psi_{2i}(x_2)$,..., $\psi_{ni}(x_n)$.

We state that saving accepted indexation level U_k is upper in relevance to $U_k^{'}$, if $k < k^{'} \left(U_k > U_k^{'}\right)$. There is may be stated that set of levels (3) of the system U is arranged

$$U_1 > U_2 > \ldots > U_n,$$

Top-down and down-top relationship of which is described with the functions φ_{ij} and ψ_{ij} $(i, j = 1,2,\ldots,n)$ it is not restricted by the interaction of adjacent levels.

State x of the system U is called theoretical or system solution, if x is a fixed point of multivalued mapping φ, i. e. $x \in \varphi(x)$. If the set of fixed points of φ mapping is not empty $(F_{ix}\varphi \neq 0)$, then U system is solvable.

Hierarchical system is potentially controlled in x state when there is $z \in \psi(x)$ control, that $z(x) \in \psi(z(x))$is completely controlled in the x state, if $\forall \omega \in \Omega \quad \exists z \in \psi(x)$, then $z(\omega(x))$ - fixed point mapping φ.

In general, control of hierarchical system can be understood as finite sequence of controls $z_1, z_2, \ldots, z_p$, that changes x state of the system to x_p state in such way that

$$z_i(x) = x_1, \; z_l(x_{l-1}) = x_l \;\; (l = 1, 2, \ldots, h).$$

If we introduce into consideration the weight function

$$f : Z \to R$$

of the set Z onto the set of real numbers, then we can talk about management "cost", for example, and we can solve the problem of optimal management in the hierarchical systems.

U system solvability requires $(F_{ix}\varphi_{11} \neq 0)$. If $x = (x_1, x_2, \ldots, x_n)$ – fixed point of the mapping φ, then $x_1 \in \varphi_1(x)$. Under the definition of φ_1

$$\varphi_1(x) \cap \varphi_{11}(x_1) \neq 0 \text{ и } \varphi_1(x) \subseteq \varphi_{11}(x_1).$$

Therefore $x_1 \in \varphi_{11}(x_1)$.

Let put $x_1, x_2, \ldots, x_n$ as nonempty compact convex sets in the Banach spaces $x_1, x_2, \ldots, x_n$. Then in order for the hierarchical system (1) to be solvable it is enough for mapping (2) φ_{ki} $(1 \leq i, \; k \leq n)$ to be closed and convex.

Under these conditions indeed the set of states X of hierarchical system is compact convex set in the Banach spaces $x = \prod_{i=1}^{n} x_i$.

Under the definitions of mappings φ_j $(j = 1, 2, \ldots, n)$, for all nonempty $x \in X$ $\varphi_j(x)$ and for every j

$$\exists_k : \varphi_j(x) = \bigcap_{i=1}^{k} \varphi_{ij}(x),$$

therefore $\varphi_j(x)$ is closed and convex likewise a nonempty intersection of convex sets. Then $\varphi = \mathop{\Delta}_{j=1}^{n} \varphi_j$ mapping satisfies closure and compactness conditions. According to fixed points Kakutani theorem : $F_{ix}\varphi \neq \varphi$.

Conclusions

The suggested approach allows with the utmost generality to consider the problem of complex system description, which includes IPSM, gives an opportunity for providing obtained design with specific mathematical structure that facilitates detailed study and obtaining exact results, provides timetable and money reduction.

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