INFORMATION TECHNOLOGIES OF INTEGRATION OF MANAGEMENT METHODS BY ORGANIZATIONAL AND TECHNICAL (TECHNOLOGICAL) SYSTEMS

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ABSTRACT

The article considers the possibility of using information technologies for the integration of management methods by organizational and technological (technological) systems, as well as the problems that arise in the study of complex mechanisms of their management. The expansion of the classification of organizational-technical (technological) systems which ensue during the devolution from the considered separate mechanisms of management to the complex ones, is proposed. Thus, if some elementary mechanism is used in the basic model then the transition to one or the other of the first four expansions of the base model raises the problem of the complexation of elementary mechanisms — the construction of a new complex mechanism, represented in the form of a set of interconnected elementary mechanisms.

Particular attention is paid to modern control theory with different number of agents and mechanisms, when the increase of the number of agents and the number of mechanisms, it's expedient to consider as a classification for systematization of the results of modern theory of management of the OTS.

The problems of coordination of systems of technological complex with consideration of different situations are analyzed. The opportunity to carry out situational management based on the automation system for stabilization of technological variables and decision maintenance of support subsystem has been proved.

The expediency of using the subsystem of the development of neuro-fuzzy ANFIS structures was substantiated, which allowed to use fast algorithms for teaching neural networks based on the method of reverse error propagation.

The possibility of combining the modern methods of automated control theory and intellectual information technologies for obtaining of new results concerning the effective process of managing complex technological objects — technological complexes of continuous type in the class of organizational and technological (technological) systems is proved.

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ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ КОМПЛЕКСУВАННЯ МЕТОДІВ КЕРУВАННЯ ОРГАНІЗАЦІЙНО-ТЕХНІЧНИМИ (ТЕХНОЛОГІЧНИМИ) СИСТЕМАМИ

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У статті розглянуто можливість використання інформаційних технологій для інтеграції методів управління організаційно-технологічними (технологічними) системами, а також проблеми, що виникають при вивченні складних механізмів їх управління. Запропоновано розширення класифікації організаційно-технічних (технологічних) систем, що забезпечуються при передачі від розглянутих окремих механізмів управління до комплексних. Якщо в базовій моделі використовується елементарний механізм, то перехід до того чи іншого з перших чотирьох розширень базової моделі породжує проблему комплексування елементарних механізмів — побудову нового комплексного механізму, що представлений у вигляді сукупності взаємозв'язаних елементарних механізмів.

Особливу увагу приділено сучасній теорії керування для різної кількості агентів і механізмів. При збільшенні числа агентів і механізмів їх доцільно класифікувати для систематизації результатів сучасної теорії керування ОТС.

Проаналізовані задачі координації систем технологічного комплексу з урахуванням різних ситуацій. Доведено можливість здійснювати ситуаційне управління на основі системи автоматизації для стабілізації технологічних змінних і підсистеми підтримки прийняття рішень. Обґрунтовано доцільність використання підсистеми розробки нейронечітких структур ANFIS, що дало змогу застосовувати швидкі алгоритми навчання нейронних мереж, засновані на методі зворотного поширення помилки.

Доведено можливість об'єднання сучасних методів автоматизованої теорії керування та інтелектуальних інформаційних технологій для отримання нових результатів ефективного процесу керування складними технологічними об'єктами — технологічними комплексами неперервного типу в класі організаційно-технічних (технологічних) систем.

Ключові слова: організаційно-технічні (технологічні) системи, комплекси, інформаційні технології, технологічні комплекси, управління.

Formulation of the problem. In the automation of productions of various purposes in the food industry, technological complexes (TC) are distinguished in a separate class as an organizational-technical (technological) system (OTS). Known works dealing with various aspects of automation of certain technological processes and industries, but for continuous processing complexes (sugar, alcohol industry, etc.), such issues were not considered in conjunction with information technologies. The possibility of integrated use of existing methods and principles of management for obtaining new, more advanced systems is also considered.

In the known works for technological complexes of food industries automation tasks were considered, but insufficient attention was paid to the use of information technologies [1]. In systems for different purposes for managing technological and production processes, information technologies provide an opportunity to increase their emergence. In turn, the effect of the emergence, allows the system to acquire new (emerge) properties, which has none of its subsystems, but this is not a simple summation of the properties of individual parts, including used methods.

The aim of the research. Analysis of existing methods of managing complex technological objects, taking into account their advantages that can be complex, for obtaining control systems with new qualitative properties, but as a class of organizational and technological (technological) systems, with an assessment of the effectiveness of increasing the incidence of emerge through the use of information technologies and ensuring resource- and energy- efficiency, taking into account requirements for the volume and quality of products.

Presentation of the main results of the research. Under management from a variety of control systems distinguish a class of organizational and technological (technological) systems [2—4]. The importance of these systems is that information systems are part of them as components and, in fact, any enterprise, firm, corporation is such a system. In other words, real management is the management of complex organizational and technological (technological) systems, which in fact is the main source of improving the technical and economic indicators of the enterprise as a whole.

For the possibilities of complexing different methods and technologies and increasing the efficiency of production under the organizational-technical (technological) system (OTS), it is appropriate to understand the artificial, self-organizing, dynamic, organizational and technical set of interconnected elements intended for the production of commodity products, the provision of services or other activities that is executed by a person [5].

Systems of this type have the following properties and features:

- the variability in time of its own structure and functions performed;
- incomplete alignment of its structure with the objectives of the time-varying system or the vector of goals of the changing system;
- the variability of the goals of operation, due to changes in the environment or the actions of competitors;
- incomplete information on the operating conditions of the system;
- incomplete of formal criteria for decision-making on maintaining integrity and system development;
- inconsistency of decisions of the decision-maker (DM), whose actions may not respond predetermined goals and made decisions can provide a negative influence on the system;
- intelligence — means that with the accumulation of experience in the functioning of the OTS, there is an opportunity to improve its actions;
- the principle of “single management” means that in each complex organizational-technical (technological) system there is only one decision-maker.

Development of control system using information technologies can be used an approach that outlined in [6]. Let's consider the basic model of the OTS, which

includes one managed entity (agent) and one governing body (center) that makes decisions once and in full informative terms (Fig. 1) [7—10]. We have: at the input — the governing influence, at the output — the action of the controlled entity (state of the controlled system).

Fig. 1. Basic model of an organizational system

List the expansion of the basic model of the OTS [9].

1. Dynamic (participants make a decisions multiple times — expansion on the subject of management “functioning”).

2. Multi-elemental (there are several agents that make a decisions simultaneously and independently — expansion on the subject of management “component”).

3. Multi-level (have a three- and more levels hierarchical structure — expansion on the subject of management “structure”).

4. With distributed control (there are several centers that manage the same agents — expansion on the subject of management “structure”).

5. With uncertainty (the participants are not fully informed about the existing parameters — expansion on the subject of management “awareness”).

6. With restrictions on joint activities (there are global constraints on the collective choice of agents for their actions — expansion on the subject of management “the set of permissible strategies”).

7. With information message (one of the agents’ actions is to communicate information to each other and/or to the center — expansion on the subject of management “the set of acceptable strategies”).

Thus, if the basic model uses some elementary mechanism, then the transition to one or the other of the first four expansions of the base model (each of which can be regarded as a set of interconnected base models) raises the problem of the complexity of elementary mechanisms — the construction of a new integrated mechanism that presented in the form of a set of interconnected elementary mechanisms.

Another expansion of the model should be assumed the consideration of a comprehensive mechanism which is decomposed into a set of basic — OTS with a complex mechanism. However, unlike the expansions listed above, this expansions can not be applied to the basic OTS model; its application should be considered with one of the first four expansions of the base model. Increasing the number of agents and the number of mechanisms to systematize the results of the modern theory of OTS management, it is expedient to consider the classification given in Table.

Table. Expansions of qualification for complex mechanisms

Composition of the UTS	Complex of mechanisms
One center, one agent	Dynamic OTS with one agent and integrated mechanism. The center with one agent implements complex interaction, which can be considered as a dynamic OTS, in which at different stages the agent and the center interact within different mechanisms of control.
One center, several agents	Multi-element OTS with integrated mechanism that is decomposed by agents. The center interacts within the framework of each base mechanism or “subcomplex” of the mechanisms from which the complex is composed, with only one agent (or a subset of non-intersecting agents), a “catena” of subsystems are formed in the OTS.
	Multi-element OTS with integrated mechanism that is decomposed by mechanisms. The center implements equally complex interaction with each agent. The “classical” festive structure of the OTS is maintained.
	Multi-element OTS with integrated mechanism. The complex structure of an intersection of a subset of agents for each of the basic mechanisms.
	Multi-level OTS with integrated mechanism. Consideration of the basic mechanisms that related to the complex, there is a «delegation» of authority: within the framework of separate basic mechanisms, individual agents become intermediate-level centers and they allocate their subordinates from a subset of agents. At the same time, at different levels of the hierarchy different situations are possible from other sections of this classification.
A few centers, one agent	OTS with distributed control and with integrated mechanism that is decomposed by the centers. Within each base mechanism, an agent interacts with one center or subset of non-intersecting centers.
	OTS with distributed control and with integrated mechanism that is decomposed by mechanisms. All centers implement the same complex interaction with each of the agents. The “classical” festive structure of the OTS is maintained.
	OTS with distributed control and integrated mechanism. The complex structure of the intersection of a subset of centers for each of the basic mechanisms.

Also, complex mechanisms need to address a number of common problems:

- admissibility (satisfaction of system constraints);
- consistency (sufficient information, “concordance” of consistent inputs and outputs, acyclicity of decision-making procedures);
- completeness and optimality;
- operational (the possibility of a solution for an integrated mechanism of the synthesis problem, preferably analytical);
- imitation (stability) of the properties of mechanisms in relation to complexation / decomposition.

Procedures for the integration of various technologies and methods should be considered in various productions. For example, in [11] we considered the tasks of coordinating systems of the technological complex taking into account situations. The design of control systems is based on the following provisions:

TC as a control object has a hierarchical structure that can be described at the conceptual level as follows: process operator (elementary technological process) → general technological process (technological unit) → technological subsystem (branch) production (main, auxiliary) → enterprise (plant);

- in assessing the state of subsystems and TC as a whole, cognitive maps, fuzzy cognitive maps, counseling systems with fuzzy logic in the class «situation-action» or «situation-strategy-control-action» are used. Then the control system itself is not explicitly given, but implemented with the help of a fuzzy situational network in the form of a fuzzy weighted graph of transitions in reference situations depending on the initial and target situation;

- situations in which TC and its subsystems can be located are determined by the set of factors that are caused by technological deviations from the estimated (optimal) technological regimes, technological equipment (wear, breakage), power supply (steam, electricity, their cost and quality), the state of the automation system (technical means of software and information support);

- the determining factor is not only the identification of the situation (its identification), but also the forecasting of the development and adoption of adequate operational management decisions;

- for each department (subsystems of TC), several tens of technological variables and other assessments (equipment, power supply, automation) can be identified, which together determine the state of the object.

Accordingly, modern management is based on the automation system for stabilizing technological variables and the subsystem of decision support, which in turn allows for situational management [12].

Fuzzy situations are determined on the basis of the set of signs $\{y_1, y_2 \dots y_p\}$ the meaning of which describes the situation (state of the object, environment, control system). The fuzzy situation is described by a fuzzy set of the second level:

$$\tilde{S} = \{\mu_s(y_i) / y_i, y_i \in Y \quad (1)$$

$$\mu_s(y_i) = \left\{ \mu_{\mu_s} \left(T_j^i / T_j^i \right), T_j^i \in T_i, \right\}$$

where: $\mu(y_i)$ — the corresponding membership functions, T_i — term-set of linguistic variables. To describe the term-sets $T_i = \{T_1^i, T_2^i \dots T_m^i\}$, D_i is formed — the base set of signs (the subject scale). Thus, by fuzzy situations states are setted in which the objects, the external environment and control system are located.

In turn, the integration of automation methods based on intelligent information technologies is considered as an analysis of the process of functioning of a complex technological object [13]. It is taken into account that the technological complex of the sugar plant has almost 400 points of control of technological variables and requires the implementation of almost 250 management functions, including automatic control [14]. The technological complex has a hierarchical structure, which corresponds to elementary technological operators, technological processes, branch (subsystems) and TC as a whole. According to this structure the structure of the integrated control system is developed, which implements a

number of functions of control, management, processing of current information, obtaining recommendations for the management of TC and its subsystems. Modern management theory determines, in addition to traditional tasks, such important functions as the definition of the state of a complex object, the current production situation and its development.

Consider the technological complex of sugar production (its parametric scheme is shown on Fig. 2.).

Fig. 2. Parametric scheme of the main flows

The solution of this problem is carried out by using an instrumental environment Matlab. The device underlying the construction of these networks has the following main advantages, namely: the possibility of a flexible interpretation of the causal relationships generated on the basis of the neuron-fuzzy structure and the opportunity to study the developed structure.

In order to solve the problem, it is proposed to use the internal Matlab environment subsystem — the Adaptive-Network-Based Fuzzy Inference System (ANFIS) -application network fuzzy conclusion. It was proposed by Jang in the early nineties [15]. ANFIS is one of the first variants of hybrid neuro-fuzzy networks — a special neural network of direct propagation of a signal of a special type. The architecture of a neuro-fuzzy network is isomorphic to a fuzzy knowledge base. In neuro-fuzzy networks, differentiated realizations of triangular norms (multiplication and probabilistic OR), as well as smooth membership functions are used. This allows for the use of neural-fuzzy networks to set up fast algorithms for training neural networks based on the method of reverse error propagation. The following describes the architecture and rules for the operation of each layer of the ANFIS network.

ANFIS implements the system of fuzzy conclusion of Sugeno in the form of a five-layer neural network of direct propagation of the signal: the first layer — the terms of the input variables; second layer — antecedents (parcels) of fuzzy rules; the third layer is the normalization of the steps of the rules; the fourth layer — the conclusion of the rules; the fifth layer is the aggregation of the result obtained by different rules.

The inputs of the network in a separate layer are not allocated. On Fig. 3 depicts an ANFIS network with three input variables (x_1 , x_2 , and x_3) and a set of fuzzy rules. For the linguistic evaluation of the input variable x_1 , 3 terms are used, for the variable x_2 — 3 terms, for the variable x_3 — 3 terms.

Enter the following symbols required for further explanation: $x_1, x_2, \dots, x_n$ — network inputs; y — the output of the network; $R1: IF \ x_1 = a_{1,r} AND \dots AND \ x_n = a_{n,r} THEN \ y = b_{0,r} + b_{1,r}x_1 + \dots + b_{n,r}x_n$ — fuzzy rule with serial number r ; m — number of rules, $r = \overline{1, m}$; $a_{n,r}$ — fuzzy term with the function of belonging $\mu_r(x_i)$, used for linguistic evaluation of the variable x_i in the r -th rule; $b_{q,r} (r = \overline{1, m}, q = \overline{1, n})$ — real numbers in the conclusion of the r -th rule $(r = \overline{1, m}, q = \overline{0, n})$.

Fig. 3. Structure of the neuro-fuzzy network

The output of each node of the first layer of the network is the degree of membership of the value of the input variable corresponding to the fuzzy term:

$$\mu_r(x_i) = \frac{1}{1 + \left| \frac{x_i - c}{a} \right|^{2b}}, \quad (2)$$

where: a , b and c — parameters of belonging functions.

The second layer of the network is a set of logical rules that determine the main cause-effect dependencies. The outputs of nodes of this layer are indicated $\tau_r, r = \overline{1, m}$.

The nodes of the third layer calculate the relative degree of execution of fuzzy rule:

$$\tau_r^* = \frac{\tau_r}{\sum \tau_j}. \quad (3)$$

A node in the fourth layer calculates the contribution of one fuzzy rule to the output of a network:

$$y_r = \tau_r^* \cdot (b_{0,r} + b_{1,r}x_1 + \dots + b_{n,r}x_n). \quad (4)$$

In turn, the output of the network counts the total result on the outputs of all rules:

$$y = y_1 + \dots + y_r + \dots + y_m. \quad (5)$$

Typical neural network training procedures can be used to configure the ANFIS network because it uses only differentiated functions.

These examples show that it is objectively possible to combine modern methods of automated theory of management and intelligent information technology to obtain new results in terms of efficient production (resource and energy efficiency), and from the standpoint of system analysis - this corresponds to a purposeful increase in the complexity of the management process's emergence technological objects - technological complexes of continuous type in the class of organizational-technical (technological) systems.

Conclusions

The technological complexes of the continuous type are distinguished and analyzed in the class of organizational-technical (technological) systems, as a result the possibility of joint use of modern methods of managing complex objects has been obtained. The presented approach is uniquely used for technological complexes of continuous type, for application on objects of other types — its certain adaptation is necessary. The addition of information technology to traditional automation systems enables the acquisition of new system properties, for example, the development of intelligent subsystem of decision-making support that based on, in particular, situational management. This method deserves special attention in the development of intelligent subsystems of decision-making support for different levels and purposes, as well as the integration of methods for forming management influences in complex automated systems.

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