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System task of creating intelligent management of complex technological procedures

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Abstract. The article is devoted to the possibility of the use of intelligent systems to optimize the processes of technological complex of sugar mill. Successful management of complex technological systems is not possible today without the constant, objective and comprehensive information. In order to increase efficiency and minimize the costs of managing the production process, it is necessary to develop an information system that helps to monitor the process. Identified tools and implementation conditions that provide the maximum achievable efficiency of management of technological complexes with the use of intelligent technologies. Management feature provides for the implementation of effective management in regular and emergency situations. For a clear understanding of management selected structural approach that separates process hierarchy and subordination of action. An algorithm for intelligent system operation while minimizing the impact of the decision maker, based on expert judgment and described the set of embodiments, based on the current state. A sequence of steps in modeling the transition of the object at different stages based on the current state of the process. A simulation of alternative solutions recommendations to the decision-maker on the basis of the process, which can be estimated on the optimal model of the object. Situational approach took into account the decision-making when the fuzzy situation, determined on the basis of a plurality of features of the current state of the process. The implemented approach allows to use an iterative analysis and translate the object in a particular state on the model in the process of working with experts. It is noted that there is an urgent need for the development of intelligent decision-making systems of difficult technological processes containing formalized difficult conditions and high demands on the quality of management.

Key words: intelligent system, technological complex, sugar mill, process, expert, decision-making, situational approach, simulation modeling.

Introduction. Permanent complication facility management in complex organizational and technical (technological) systems objectively leads to the necessity to use one of the most promising areas of modern management theory - intelligent systems of various types and purposes.

The article discusses the technological complex (TC) of a sugar factory, continued use during the season is characterized by significant material flows, energy consumption, which generates significant flow of information to measure and maintain the required level of several hundreds of process variables of different nature (temperature, level, flow, pH, etc.) to provide a set (optimal) process conditions, under all sorts of uncertainties, disturbances and risks.

Viewed TC refers to a class of complex systems with a hierarchical structure, the presence of individual interconnected subsystems with their mathematical models, performance and operation criteria. Various methods are used to identify the TC process operation, for example, adaptive neural network [1]. In the development of functional structures of control systems necessary to provide the algorithms as the usual stabilization of technological modes and methods of contingency management [2], precedential, adaptive etc. which ensures the stability of technological processes under uncertainty and decisionmaking both in-house and in emergency situations [3]. The overall framework for the implementation of these methods and compounds them into a single system is an intelligent technology, synthesized on the basis of a systematic approach and methods of modern control theory.

Materials and methods. System task of forming TC intelligent control procedures include a number of stages, the first is the system analysis of TC as a complex control object with reasonable administration of sub-systems, evaluation of functioning process, the identification of a set of situations that arise in production, taking into account the uncertainties of different nature and their impact on the management.

In the design process of TC management systems have to take into consideration a complex of conflicting requirements on sustainability indicators and quality of functioning processes, simplicity, reliability, types of support (information, software, organizational) and serviceability and others.

The article used a systematic approach, which consists in the fact that an intelligent control system (ICS) is an effective means to ensure achieving the maximum amount of control on the upper level and a minimum flow of useful resources on the lower (executive) level of hierarchical automation system "technological object + controller". On the substantive level, such a statement reflects the purposeful functioning of ICS in the general contingency (emergency) situations. The decisive role here is played by the level of intelligence of the developed system in the first place, shape, and depth of knowledge representation [4, 5].

For technological objects ICS should have an increased capacity for work, which ensures the maintenance of the required technological modes in the standard (in-house) and contingency (emergency) situations. Distinctive importance is to increase an operability of automatic controllers (P, PI, PD, PID) on the lower level, which leads to an additional effective use of existing processes and increased economic effect. Perspective direction is the use of a hybrid ICS based on standard PID and fuzzy controllers. At the same completeness and correctness of the developed knowledge base (KB) is defined by a finite set of production rules (look - up table) a specific model of fuzzy inference with specific types and parameters of the membership functions that form the control laws for the object.

One of the important characteristics of the ICS is the level of intelligence [6,7,8] which defines the state of the functions performed by a person (who makes decisions-PMD), and implemented the software and hardware components of the control system which has a formal regular character, in contrast to the heuristics used by PMD. For technological objects intelligence level is fully determines by the effectiveness of the control system that is implemented by a combination obtained by the expert in the form of rules, "if A...THEN...B", where A and B - linguistic variables with certain membership functions. In fact, this process determines the feasibility of effective management in a variety of technological and production situations.

Recently, an approach to the development of the ICS, which can be called integration, for example, creates robust, adaptive, robust-optimal system, robust-modal regulators and etc. that on the basis of intelligent technologies makes it possible to implement:

- adaptive control with the change the structure and (or) the system parameters, including, based on precedent;
- predicting system behavior for the purpose of adjusting the operational characteristics of the control actions in the coming period, the functioning of the facility;
- diagnosis object state management and the definition of the set of eligible actions on certain periods of time;
- ensuring robust indicators of sustainability and quality of transients, the stabilization of an object in different situations;
- determining a plurality of external disturbances.

A separate task in the development of ICS is the data mining (sometimes allocated a separate time series analysis) - a multidisciplinary area originated and developed on the basis of such sciences as applied statistics, pattern recognition, artificial intelligence, database theory and etc. new aspects of the problem presented [9], where the possibility of Bayesian networks is shown, in particular, in the construction of intelligent decision support systems [10]. In this case, a systematic approach to the creation of the ICS makes it possible:

- to analyze alternative (complementary) data processing methods to maintain and improve its informational content, bringing to a convenient form, such as adjustment of the distribution (the transition from uniform to a normal distribution), use of simulation methods;
- to evaluate alternative methods for determining the structure and parameters of mathematical models;
- use a variety of criteria of an assessment of model's adequacy;
- use an alternative methods of generating probabilistic conclusions and, if possible, to control activities and evaluation of the forecasts;
- justified to choose the best solutions from a variety of alternatives generated to form the final output.

Intelligent control systems have a hierarchical structure, within which implemented procedures and tasks described above. At the same time there is always a lot of options for the structure, which stands out not only the top (team) and lower (executive) levels, but also the intermediate, for example, optimization of technological modes, coordination of the subsystems etc. [11,12]. Difficulties of successful solution of these problems stem from the fact that the management decisions are always formed in a high degree of uncertainty, as the statistical nature and generated blurred formed objectives and constraints.

Given that the signal from the upper level in a well-organized system is a task for a lower level, it can be assumed that each coordinating signal γ, belonging to the set Ω, select multitude

$$U^{Y} = U_{1}^{Y} x \backslash ... \backslash xU - n - \gamma \subseteq U, \qquad (1)$$

where *i-th* - a unit of the local low-level perceives U_i^Y as an established range of disturbances, which makes it possible to combine in a single system of evaluation and prediction of interactions for a variety of subsystems. Using the method of fuzzy sets, elements of controls are fuzzy goals, membership function, fuzzy restrictions on choice of alternatives when making decisions and achieve the desired result. Decision-making problem - complex influence fuzzy goal *G* and fuzzy constraints *C* in the range of alternatives when fuzzy intersection G·C forms a fuzzy set of solutions *D*

$$D=C\times C \qquad (2)$$

Membership function for a variety of solutions is given by the ratio

$$\mu_D(x)=\mu_G(x)\wedge\mu_C(x), \qquad (3)$$

where *x* - a given set of alternatives. If *n* is generally set targets and constraints m, the result is the intersection of solutions

$$D = G_1 \cap \backslash .. \backslash . \cap G_n \supset C_1 \cap \backslash .. \backslash . \cap C_m \qquad (4)$$

$$\mu_D = \mu_{G_1} \wedge \backslash .. \backslash . \wedge V \mu_{Gn} \mu_{C_1} \backslash .. \backslash . \mu_{Cm_1} \qquad (5)$$

The functioning process of the hierarchical system can be formalized by considering the concept of sub-tasks to be solved at different levels

$$(n)E_{TC} = \{^{(n-1)}E_i, ^{(n)}E_K\}, i \in ^{(n-1)} I, \qquad (6)$$

where $^{(n)}E_{TC}$ - the task of managing the technological complex in an n-tier system; $^{(n-1)}E_i$ - subtasks of management subsystems of TC; $^{(n)}E_K$ - the task of coordination.

One of the main criteria for the formation of the TC Intelligent management procedures is a situational approach, when the fuzzy situation, determined on the basis of a plurality of features $Y=\{Y_1,Y_2\backslash.\backslash.\backslash.Y_p\}$, which values to describe a situation (state of the object, the environment, management systems). Fuzzy situation described by the fuzzy sets of the second order

$$(S' = \{\langle \mu_{\downarrow} S(y_{\downarrow} i) / y_{\downarrow} i \rangle\}, y_{\downarrow} i \in Y, @\mu_{\downarrow} S(y_{\downarrow} i) = \{\langle \mu_{\downarrow} (\mu_{\downarrow} S) \qquad (7)$$

where $\mu_S(y_i)$- the corresponding membership functions; T_i - term-set of linguistic variables. To describe the term set $T_i = \{T_1^i, T_2^i \backslash.\backslash.\backslash.\backslash.T_m^i\}$ formed D_i- a basic set of features (objective scale). Thus fuzzy situations set a state, in which are objects, the external environment and the control system.

On basis of projection of control systems based on the following provisions:

- TC as a control object has a hierarchical structure, which at the conceptual level can be described as: the process operator (simple process) → overall process (process unit) → technological subsystem (department) → production (main and auxiliary) → company (factory);

- Assessing the state of subsystems and TC in general, cognitive maps and fuzzy cognitive maps are used, the council system with fuzzy logic in the class "situation-action" or "situation-action-management strategy." Then the control system itself is not explicitly given, and is implemented by using fuzzy situational network as a fuzzy weighted graph of transitions on the reference situation, depending on the initial situation and the target;

- situations in which TC can be and its subsystems are determined by many factors, resulting by technological deviations from the calculated (optimal) process conditions, the state of technological equipment (wear, damage), maintenance of energy (steam, electricity - their flow and quality), state of an automation system (hardware and software information support);

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

- for each department (TC subsystem) can identify several dozen process variables and other changes (equipment, power supply, automation), which together determine the state of the object.

On this basis, modern management system is based on the automation system for the stabilization of process variables and decision support subsystem, which in combination makes it possible to carry out contingency management.

Results and discussion. In controlling TC determines the value of a magnitude of the material flow between the subsystems and its deviation from the set value.

If the object is in a situation S_j with lots of fuzzy characteristic values $y=\{Y_1,Y_2\backslash.\backslash.\backslash.Y_K\}$, it is necessary to determine in which situation S_j (it) will pass the implementation of fuzzy management decisions $R=\{R_{D_i}^{G_i}, R_Z^{RK}, R_{G_2}^{G_j}\}$, for example, where $R_{D_i}^{G_i}$ - "to reduce the number of" "flow" of the i-th substance;

R_Z^{PK}-"don't change" "pressure" of component K_j;

$R_{G_2}^{G_j}$ - "greatly increase" the "consumption" of j-th substance. In this case the object will pass a number of intermediate situations $S_{D_1}^j \to S_z^j \to S_{e_2}^j$ when sequential management decisions are implemented $R_{D_1}^{G_j} \to R_z^{PK} \to R_{e_2}^{G_j}$.

A common approach to the implementation of these procedures is demonstrated on this example. Figure 1 and Figure 2 shows the membership functions of linguistic variables "change of loss" and "loss".

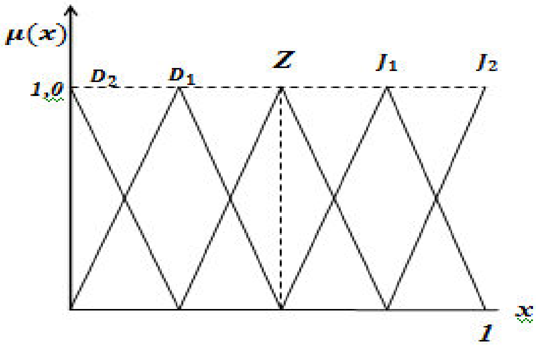

Figure 1. Term-set of the linguistic variable "change of loss"

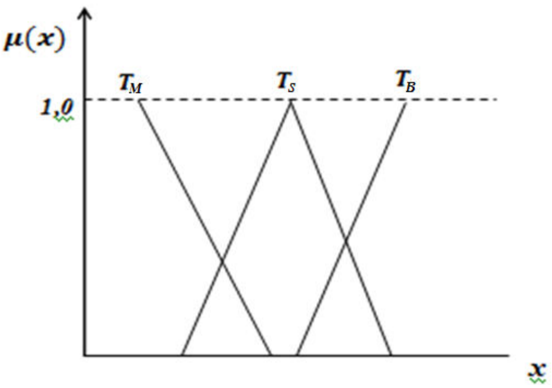

Figure 2. Term-set of the linguistic variable "loss"

Fig. 1 is indicated: D_2- "substantially reduce"; D_1- "some reduce"; Z- "Don't change"; I_1- "slightly increase"; I_2- "significantly increase".

Fig. 2 is indicated: T_S- "small"; T_M- "middle"; T_B - "big". Figure 1 Figure 2 is the accessory functions are triangular in shape, and in specific cases, it may be a different shape, for example exponential.

Sequencing in modeling the transition from the object situation S_i which is determined by a variety of fuzzy characteristic values $Y_i = \{\widetilde{T}_i, \widetilde{P}, \widetilde{C}_i\}$ into the situation $S_{D_i}^j$ as the result of administrative action $R_{D_i}^{G_j}$ - "to reduce the number of" "flow" ($\widetilde{T}_i, \widetilde{P}, \widetilde{C}_7$ - linguistic variables: temperature, pressure, concentration, respectively) realized the following stages:

etermined flow fuzzy value G_{i+1} provided that the flow rate G_i is measured in a quantitative manner, for example, $R_{D_i}^{G_j}$ - "to reduce the number of" "flow" G_{i+1}will be

$$G_{i+1} = \left(G_i \wedge R_{D_i}^{G_j}\right) \cdot R_{EU} \qquad (8)$$

where R_{EU}- the ratio of an execution unit;

based on the fuzzy model is carried forward chaining

$$\widetilde{T}_i = G_{i+1} \cdot RT; \widetilde{P} = G_{i+1} \cdot R_{pi}, \ \widetilde{C} = G_{i+1} \cdot R_c, \quad (9)$$

where R_T, R_p, R_c- fuzzy ratio that defines the interconnection of material flow, respectively, the temperature, pressure and concentration.

Thus, the linguistic variables $\widetilde{T}_i, \widetilde{P}_i, \widetilde{C}_7$ are defined and their values that correspond to the new one $S_{D_1}^j$. Prediction of situations S_z^j, S_{ez}^j during successive management $R{\downarrow}Z^{\uparrow}(P{\downarrow}K)(R{\downarrow}(e{\downarrow}2)^{\uparrow}(G{\downarrow}j)$ activities in similar way.

Conducted simulations on the results of alternative solutions provides recommendations for PMD, and their optimality can be estimated on the object model. The approach allows the use of an iterative analysis and transfer the object in a particular state on the model in the process of working with experts.

Conclusions.

1. Intelligent technological complexes control systems have a hierarchical structure that ensures the implementation of an effective methods of increasing the technical and economic performance of an object in the class of organizational and technical (technological) systems.

2. Formation of the TC Intelligent Control procedures are based on a combination of system analysis methods and modern management theory and provides the functions of research facilities on the basis of neuronal and neuro-fuzzy systems with the implementation of the identification of problems of adaptation, coordination, forecasting, case and situational management.

3. For the TC of continuous type change of the material flow is an effective control action, in the article is an example of this problem, using methods of fuzzy logic.

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