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OPERATIONAL MANAGEMENT OF TECHNOLOGICAL COMPLEXES BASED ON THE EVALUATION OF NOISE IMMUNITY OF INFORMATION AND CONTROL SYSTEMS

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ANNOTATION

The concept of noise immunity of objects of operational dispatching control of complex technological processes and productions from the point of view of possibility of performance of planned tasks on the basis of an assessment of reliability characteristics of technological knots is entered. It is shown that the application of the fuzzy set theory apparatus to assess the noise immunity of the system under study makes it possible to assess the production situation not only in the presence of objective statistical information about perturbations on the system, but also on the basis of subjective information.

Keywords: operational dispatch control, chemical-technological complexes and installations, noise immunity of the control object, technological and production losses from disturbances, technological developments, continuous nature of production.

Analysis of existing information management systems indicates that their effectiveness is determined primarily by the solution of problems of operational control (ODE) in many cases are unsatisfactory, because they do not take into account the real complexity of production processes, the dynamics of changes in resources, the presence of uncertain, but have a significant impact on the course of the process factors. In General, methods for solving control problems of complex chemical-technological complexes operating under conditions of uncertainty of input and output parameters of the object remain poorly developed; there are no universal algorithms for solving these problems. In this regard, relevant research aimed at developing methods for constructing mathematical descriptions of complex technological objects, the choice of performance criteria and the creation on this basis of more advanced algorithms that provide optimal operational control and decision-making in real time.

Let us turn to the approach aimed at solving the problems of operational management of chemical-technological complexes and units with continuous production without recycling, consisting of interacting technological and storage units, and allowing on the basis of available objective and subjective information about the reliability characteristics of technological units to predict the results of the test object and calculate the optimal control actions that provide the ability to compensate for losses from the expected disturbances.

In the implementation of operational management Manager must be able to assess the situation in terms of the ability to perform the planned tasks available to its resources. The paper [1,2] introduces the concept of noise immunity of chemical-technological systems, which is defined as the properties of the object to function effectively under the conditions of internal and external interference. In accordance with the positions of the authors of this work and the chosen approach to solving the problems of compensation for losses from disturbances under noise immunity of the technological node Π_i at any time t of the dispatching shift $[D,T]$, we will understand its ability to perform planned tasks without introducing control effects on the interval $[t,T]$ in the conditions of possible occurrence of disturbances.

This concept is a qualitative characteristic of the control object. In order to effectively use noise immunity for management decisions, it is necessary to have its quantitative assessment.

To simplify the calculations, we assume that all the parameters of the technological complex (such as, for example, as the planned tasks A_i, maximum g_i^{max} and current $g_i(t)$values of workings, as well as the minimum S_j^{min}, maximum S_j^{max} and current $S_j(t)$values of the filling levels of drives) are converted to the same product (in most cases, it is the final product) by means of consumption norms.

We introduce the exponent of the technological node Π_i planned target A_i

$$r_i = \frac{G_i(T)}{A_i} \quad (1)$$

where $G_i(T)$ is the time of production during the dispatching shift ([D,T] multiplied by 100, this indicator gives the percentage of the plan).

Given that the purpose of operational control is to perform tasks Ai all technological units, as an indicator of the degree of implementation of the plan chemical-technological complex as a whole choose the value

$$r = min_i\{r_i\} \quad (2)$$

We will make a prediction of the value of the index r for the moment t_0 under the condition of the implementation of a set of disturbances with characteristics x and in the absence (in the previously accepted sense) of control actions. We will calculate the value of r on the basis of simulation of the object behavior on the time interval $[t_0, T]$.

To do this, the time interval $[t_0, T]$, taking into account the required accuracy of the calculation results, is divided into intervals equal to Δt. Values of $g_i(t_0)$,$G_i(t_0)$,$S_j(0)$drive levels and a set of characteristics of expected disturbances are used as initial data.

The simulation algorithm$[t_0, T]$provides the calculation of the characteristics of the state of the technological complex at the time $(t + \Delta t)$, that is, it allows to obtain the values of $g_i(t_0 + \Delta t)$, $G_i(t_0 + \Delta t)$, $S_j(t_0 + \Delta t)$. These values serve as initial values for the next step of the simulation algorithm. After the required number of iterations,the end of the dispatching shift and the corresponding state characteristics of the object $g_i(T)$,$G_i(T)$, $S_j(T)$ are determined.

The value of the indicator of the degree of fulfillment of the planned task by the technological complex is calculated in accordance with the expressions (1) and (2)

$$r(x) = min_i\left\{\frac{G_i(T)}{A_i}\right\}. \quad (3)$$

Thus, each possible set of failures of technological units, given a set of characteristics x, can be put in accordance with the indicator $r(x)$. In other words, the algorithm simulating the operation of the technological complex allows to construct a mapping from a set of possible sets of characteristics for the dispatch interval of the change sets of failures X in the region of non-negative real numbers R^1.

Select a subset in this set

$$X_a = \{x\epsilon X \div r(x) \geq a\} \quad (4)$$

it is a set of those x, in which the value of r exceeds a given value.

The most objective assessment, which can be chosen as a measure of noise immunity Z_a chemical-technological complex for the value of the indicator of the degree of implementation of the target, equal to a, is the probability that $r \geq a$.

In the adopted notation

$$Z_a = \int_{X_a} a' p(x)\, dt, \quad (5)$$

where $p(x)$ is the continuous density distribution of the probability of failure of technological units.

However, the computational difficulties associated with obtaining the density distribution of the failure probability of technological units and failure sets at the interval of one dispatching shift, prevent the use of the noise immunity criterion in the form of (5) for the formulation and solution of problems of compensation for losses from disturbances within the framework of the adopted approach.

One of the ways to overcome these difficulties, in our opinion, is the use of elements of the mathematical apparatus of the theory of fuzzy sets. In addition to simplifying purely computational operations, this device allows you to enter into the processing of "non-statistical" information, for example, such as a subjective assessment by the dispatcher of the possibility of failures and their parameters (duration and magnitude of reduction in output). At the same time, the mathematical apparatus of the theory of fuzzy sets does not exclude the possibility of using the available statistical information about the reliability characteristics of the technological elements of the control object.

Instead of the probability density function *p(x)* of the implementation on the interval of the dispatching change of failure sets with a set of characteristics *x*, we will use the estimate *μ(x)* of the possibility of such implementation.

The construction of the *μ(x)* function is carried out on the basis of the information available to the dispatcher about the characteristics of possible failures of technological units. This information can be obtained in the processing of statistical data, by means of an expert survey, as a result of the analysis of records in the dispatching log of failures and activities carried out to eliminate them in the previous shift.

Since the determination of estimates of the possibility of implementing a set of failures of technological units is a very difficult task, we divide it into several stages.

At the first stage, the possibility of failure occurrence $\varphi_i$separately in each of the technological units of the complex at the interval of the dispatching shift [*D*,*T*] is estimated. It is necessary to construct a continuous function $\varphi_i(t)$, such that

$$\int_0^T \varphi_i(t)dt \leq 1. \quad (6)$$

As $\varphi_i(t)$, it is desirable to take the probability density distribution function of the failure-free operation of the process unit $П_i$. In most cases for continuous production it can be assumed that

$$\varphi_i(t) = const. \quad (7)$$

This is tantamount to the assumption of the uniformity of the probability distribution of failure-free operation of technological units in the interval [*D*,*T*].

Evaluation of the possibility of failure in the period of time$[t_1, t_2]$is calculated by the formula

$$\Phi_i(t_1, t_{2)} = \int_{t_1}^{t_2} \varphi_i(t)\, dt \quad (8)$$

At the next stage, for each type of failure $\left(g_{i,ki}^B, t_{i,ki}^B\right)$, its share λ_i in the total failure flow of this process unit is determined. It is obvious that the characteristics $\lambda_i$must satisfy the condition

$$\sum_{k_i=1}^{K_i} \lambda_i \left(g_{i,ki}^B, t_{i,ki}^B\right) = 1. \quad (9)$$

The definition of the *μ(x)* function completes the following constructions.

Fix on the time interval *[D,T]* moments

$$t_m = m \cdot \Delta t \quad (10)$$

where m=1,2,…,*a*, - Δt is the step chosen for the simulation model taking into account the required accuracy of the calculations.

Each possible perturbation of the technological node $П_i$, characterized by the parameters $\left(t_{m_i}, g_{i,ki}^B, t_{i,ki}^B\right)$, we put in accordance with the value

$$V_i\left(t_{m_i}, g_{i,k_i}^B, t_{i,k_i}^B\right) = \Phi_i\left(t_{m_i}^{-1}, t_{m_i}\right) \cdot \lambda_i\left(g_{i,k_i}^B, t_{i,k_i}^B\right) \quad (11)$$

This value estimates the possibility of a perturbation at the time t_{m_i} at which the production of the process node $П_i$ during the recovery interval with a duration of $t_{i,ki}^B$does not exceed the value of $g_{i,ki}^B$.

The function *μ(x)*, which characterizes the possibility of a set of failures with a set of characteristics *x*, is determined by estimates of $V_i$of individual disturbances included in this set.

Thus

$$\mu(x) = \underset{i\,=\,1,\,\dots,\,M_i}{\odot} V_i\left(t_{m_i}, g_{i,k_i}^B, t_{i,k_i}^B\right) \quad (12)$$

where ⊙ is either the multiplication operation (when probabilistic interpretation ofV_i) Estimates) or the min operation (if V_i)is constructed on the basis of information of a "non-statistical" nature).

Consider for an arbitrary moment of time $t_0$some fuzzy subset $E_0 < X$, the carrier of which are the sets of characteristics x of those sets of failures that can take place on the remaining interval $[t_0, T]$ until the end of the dispatching shift. The membership function $\mu_{\varepsilon_0}(x)$, for every refusal to define according to the following rules.

If at least one technological node $П_i$set x features of a given set of failures, is the magnitude of $t_{m_i} < t_0$, then$\mu_{\varepsilon_0}(x)$takes the value zero. In other cases, when the inequality $t_0 \leq t_{m_i} \leq T$is satisfied for all technological units , the value of the estimate coincides with the value $\mu(x)$.

Apply to the fuzzy subset $E_0$the previously introduced mapping *r(x)*. According to the generalization principle of L. A. Zadeh [2,3], the image of $\gamma_0$of the map *r(x)* is a fuzzy subset of the set of non-negative real numbers with the membership function $\mu_{\gamma_0}(y)$, where $y\epsilon R^1$. Herewith,

$$\mu_{\gamma_0}(y) = \underset{x\epsilon r^{-1}(y)}{\oplus} \mu_{\varepsilon_0}(x), \qquad (13)$$

where ⊕ is either the summation operation (with probabilistic interpretation of the membership function) or the max operation (if the membership function is based on information of "non-static nature"), and the set for any $y\epsilon R^{-1}$has the form

$$r^{-1}(y) = \{x \epsilon X \div r(x) = y\} \qquad (14)$$

The fuzzy subset $Y_0$of the set $R^1$is a fuzzy estimate of the situation at time t_0. Using this estimation, we define the opportunity $Z_a$achieve a rate *r* given value a as follows [4]:

$$Z_a = \begin{cases} \sum_{y \geq a} \mu_{\varphi_0}(y) & - \text{with the probabilistic interpretation membershipfunction,}, \\ \mu_{\varphi_0}(a) & - \text{otherwise} \end{cases} \qquad (15)$$

The value of $Z_a$will be taken as a measure of noise immunity of the technological complex at a given value and the indicator of the degree of fulfillment of the planned task. This value quantitatively characterizes the possibility of achieving the goal of operational and dispatching control in the conditions of possible disturbances.

Thus, the task of operational dispatch management, which consists in selecting and coordinating the loads of technological nodes, leads to the need to analyze a large number of related parameters, and some of these parameters (such as the values of expected losses W_i) do not have clearly defined values.

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