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MODELING OF PROCESSES OF OIL REFINING UNDER OPERATIONAL MANAGEMENT ON INDICATORS OF QUALITY OF PRODUCTS

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Abstract: The main feature of oil refining industries is the instability of the characteristics of raw materials and the multi-assortment of products. At the same time, the processing mode is largely determined by the characteristics of the raw materials and the task for the production of products.

Keywords: oil, raw materials, plant, types of oil products, oil processing

Introduction. The main feature of oil refineries is the instability of the characteristics of raw materials and the multi-assortment of products. At the same time, the processing mode is largely determined by the characteristics of the raw materials and the task for the production of products. Due to the fact theat it is not possible to quickly analyze the composition of raw materials and calculate them by determining the parameters of technological regimes, oil refining is usually managed withe large margins in terms of quality indicators.

The purpose of operational management is to ensure the maximum yield of products of a given quality from the raw materials entering the plant, minimizing energy and material costs, i.e. ensuring optimal performance indicators (PE) of the process. The information on the basis of which the formation of control actions is carried out is: restrictions on the values of the parameters of the technological regime, the values of the normalized indicators of the quality of products and the PE of the process.

In practice, the way to obtain the values of quality indicators (QI) of products is to conduct laboratory analyzes of wiped samples. The frequency and time spent on laboratory analyzes withe such an organization of the information subsystem do not provide the possibility of operational management and maintenance of high PE.

The combination of raw materials withe unstable characteristics and the lack of operational information about the PC of the products obtained are the main factors theta make the task of selecting a technological mode extremely difficult. Theas. obtaining high process efficiency carriers is difficult, including due to the lack of high-quality operational information about the process. The main difficulty in promptly obtaining information about the PC is due to the lack (or extreme limitations) of quality control tools for oil refining products on stream.

The solution of the problem of operational estimation of the values of the PC of all the products involved in the process, as studies show, makes it possible to increase the efficiency of production from several to two tens of percent.

The simplest and most easily implemented way to obtain information about the PC is to calculate the required indicators for models.

The task of process control is the choice of such a technological regime, in which, under the conditions of technological limitations. the action of various kinds of disturbances (controlled and uncontrolled), the change of production tasks for the production of products, the maximum yield of the target product of a given quality is ensured at minimum energy costs, which characterizes the optimal PE of the process.

All PEs of the control system can be evaluated on a rank scale, when the rank is determined by the complexity of the operational evaluation and optimization of these indicators. At the same time, a special place in the calculation and provision of optimal technical and economic indicators (the global goal of management) is given to maintaining the specified technical so far, in particular, the PC of the products obtained. [2]

One of the main features of the processes of oil refining and petro chemistry is the great dependence of the PC of products n II") of production on the characteristics of the feedstock entering the plant. The instability of the characteristics of raw materials determines the need to change the regime parameters in order to maintain the normalized PC of the products obtained.

In the operational management of processes for PE and PC products, problems arise, first of all, in the development of the information part of the control system. Theism is due to the following reasons: 1) some process parameters are practically not amenable to accurate quantitative analysis (for example, the characteristics of petroleum feedstock), therefore, there is usually no operational ("on-stream") information about the feedstock; 2) there is no possible and operational determination of the value PC of the resulting product", which does not allow organizing feedback on the final result of production.

The following should be attributed to the problems of control subsystems in process control by PC: 1) the absence of an explicit and uniform connection between technological parameters and PC of commercial products, which determines the ambiguity of the choice of control actions; 2) The presence of a large number of restrictions on the parameters of the technological mode and PC products; 3) Limited control resources: a typical situation is when there are fewer control parameters than controllable coordinates; 4) multi-criteria of the control task: when managing the PC of products, it is required to maintain a number of PCs of one (several) oil products.

Theas, under the conditions of frequent uncontrolled change of raw materials, fundamental or technical unfeasibility of measuring the majority of PE and PC, the complexity of the control task, the existing methods of building systems do not provide control efficiency. In this regard, when managing oil refining processes, the efficient use of material and energy resources and the specified process PEs are not ensured.

The analysis of ways to solve the problem of control optimization revealed, as one of the main tasks, the need to obtain operational information about PC products. Based on the foregoing, the main task of the study is considered - the principles of building and functioning of the information subsystem of PC products for the purposes of operational management.

Based on the analysis of methods for the rapid production of PC products, it was determined theta often the only acceptable method is to determine them on the basis of indirect measurement, i.e. the calculation is indicative of the models. To calculate the PC from the models, a situational approach to modeling processes is used, which makes it possible to reduce the number of input parameters of the models, simplify the structure and procedures for identifying the coefficients of the PC models.

The task of evaluating a PC product" by situational models was divided into two subtasks: 1) determining the structure and parameters of models theta are adequate to the object. in a given area of variation of technological parameters; 2) separation of areas of adequacy of such models.

In addition, the task of training situational models is also relevant, i.e. formation of a knowledge base in the form of situational models calculation of PC products based on observations of a real object.

the development of situational models for calculating the PC of products involves the use of methods for identifying a technological situation in order to select an appropriate situational model. The paper deals with the problem of identifying a technological situation determined by the set R of input parameters, the set T of technological parameters, and restrictions on the quality of the product. Under the i - and technological situation we mean theta the current parameters from R and T belong to a certain subset $g_1, g_1 \in R \cap Ti = 1, 2$............

For oil refining processes, often not all of the indicative variables through which situations are set can be set or quickly measured, for example, the characteristics of petroleum feedstock, catalyst activity, and the so-called. (elements of the set R). In this regard, the tasks of identifying the technological situation into dependent and initial data are formulated in two settings: 1) non-measurable process parameters are set as initial information; 2) some elements of the set R are a priori unknown. [3]

In the first case, the identification of the technological situation is proposed to be carried out on the basis of the analysis of logical expressions. To do this, at first, the interval of permissible changes in each attribute variable x_1is divided into к_1, subinterval in . for each sub-singer, a Boolean variable is placed in the outer corner

$$S_{k_i} = \begin{Bmatrix} 1 x_1 \in x_{k_i} \\ 0 x_1 \notin x_{k_i} \end{Bmatrix} i = \ln .k = 1.2....$$

Then the situations can be identified based on the analysis of logical expressions $Q_p j = l.N_c$ where

$N_c = \prod_{i=1}^{n} m_i$ - the number of situations introduced into consideration, composed of variables S_{k_i} and their negations $i = l.n : k_1 = l.m_1, m_1$ - the number of situational subintervals of the variable) ;

the measured value of one attribute variable is equal to the boundary value (boundary situation of the first type);

the measured values of two attribute variables are equal to the boundary ones (boundary situation of the second type), etc.

In the general case, for n feature variables it is possible to distinguish n gnostic boundary situations. In addition, for any number n of feature variables, the boundary of the n -the type will be expressed by a point, the boundary of (n-1) type - by a straight line, (n -2)-the type - by a plane. The remaining boundary situations of a lower order will be characterized by some hyperplane.

In the first case, the situation can be uniquely identified, but since the situational model was obtained for the central values of the situational subintervals, then for the current situation it is possible and reasonable to correct the estimated values of the PC based on the consideration of the membership function of the base case. In addition, the ego provides a seamless evaluation of the PC when moving from one situation to another.

For the second case, it is necessary to correct the PC values for two situational models, for the third - for four, for the fourth - for eight, etc.

The measure of belonging of the observed situation to the basic options is estimated on the basis of logical expressionsQ_1

evaluation method is reduced to the following sequential steps: 1) Q_1conjuncts theta are inversions are excluded from the records S_{k_i}, 2) Boolean variables S_{k_i} (I) are assigned fuzzy variables withe S_{k_i} membership functions U S_{k_i} (1), having a maximum at the center of the subinterval K_13) two-valued logic operations are put in correspondence with fuzzy logic operations. Then the values of the output symbol $\tilde{Q}_j \left(j = l.N_c \right)$ can be considered as a function of membership of the current situation in the j -the base case.

The correction value is defined as

$$a_1 = \tilde{Q}_j / \sum_{r=l}^{N_c} \tilde{Q}_R \qquad (2)$$

where, a_1is the weight coefficient withe which the calculated value of the PC, obtained from the j -the situational model, will enter the corrected value

$$B^x = \sum_{j=l}^{N_c} B^{Mj} .a_j \qquad (3)$$

where is B_j^Mthe set of PC values determined by the j -the situational model for calculating PC products.

The disadvantage of the proposed correction metheod is the need to synthesize and calculate Nc logical expressions.

To reduce the amount of calculation, the following procedure is proposed.

Variables S_{k_i} for which U(S_{k_i}) ≠0 form the set

$\tilde{S} = \left\{ S^r{}_{k_i} \right\} .r = l.R : R = \sum_{i=l}^{n} p_1$ "P value, for each feature variable x_1, equal to v_1, - the number of subintervals U(S_{k_i}) ≠0. except when the value of the feature variable x_1is in the intervals $\left[x_1^R : x_1^0 \right]$ or

$\tilde{S} = \left\{ \tilde{S}^r_{k_1} \right\} .r = I.R : R = \sum_{i=1}^{n} p_1$ the lower and upper limits of the interval of variation of the variable are x_1the variation of the variable x_1in the cither of the first and last sub-intervals Then the value $p_1 = v_1 - I$ is allocated a subset of logical expressions

$Q_G = \{Q_1\}, j = I, q: \ q = \prod_{i=I}^{n} p_1 \bullet$ coo corresponding to boundary situations . To derive a subset Q_G; fuzzy set S is associated withe a set S , whose elements are logical units. The set Q_Gis formed by a complete enumeration of combinations. $S_{k_i} \in S$ According to the metheod proposed above for assessing the belonging of the observed situation to the basic options for the ones selected at the previous step, Q_Gfuzzy logical expressions are synthesized $\tilde{Q}_j j = I, q,$ and the value of PC is corrected but (2) and (3). Obviously, $q \le N_c$ the type of the boundary situation is determined on the basis of the calculated Qj

$$t = \ln N / \ln 2, \qquad (4)$$

where N is the number of fuzzy logical expressions withe the same (up to rounding errors) values.

The paper explores the possibility of correcting the calculation of the PC for situational models based on the calculation of known types of measure (distance) or current to basic situations. It is shown that this approach is more laborious and contains a large number of subjective operations, such as justifying the type of measure, the method of normalizing distances. It is advisable to use a correction based on the calculation of the distance if the cumulative influence of all variants of basic situations is estimated for the corresponding types of membership functions of attribute variables.

The method of identification characterizes the ease of implementation. At the same time, it is possible to identify the situation only in the class of measured parameters of the technological mode, which is a rather strong limitation on the use of the above methods for identifying the mode of oil refining and petro chemistry processes. Therefore, it is very important to develop approaches to solving the problems of identifying a technological situation also in the presence of unmeasured process variables, in particular, the characteristics of raw materials.

Aggregate $R \cap U$ generates a set of indicative variables P, which determine the technological situation. Significant variables named differently in interdependence withe the process, or a different rush is also important for characterizing the situation. Therefore, the whole set P can be divided into subsets p where it will determine the priority of the group of attribute variables no to the criterion of reparability of the situation, we will take a tuple of subsets p_1,p_2... establishes a rank scale for measuring these priorities.

Theus, the task of identifying a situation and choosing a situational model is divided into subtasks: I) assessing whether current parameters belong to $t^0, r^0, r^0, \in R \ t^0, \in T$ one of the subsets G_12) choosing a model from among the situational models corresponding to the $g_1^j \in G$ The first task of identification requires a solution if the subset G_1, is not directly defined through the initial information, E e solution is associated with the definition of trying on features n_1, subset P_1-

It is proposed to determine the parameters of a subset p_1based on the mapping

$$\psi\{R,T\} \xrightarrow{J_1} G_1(\eta_1), \qquad (5)$$

here is J_1the corresponding criterion, by which, from the set of $\psi\{\bullet\}$ signs formed by the operator are uniquely distinguished G_1.

The definition of the subset g , J was also proposed to be carried out on the basis of the operator $\psi\{\bullet\}$, but already in the subset Gj

$$\psi\{r_1 t_1\} \xrightarrow{J_2} g_1^j \qquad (6)$$

Here - corresponding criterion, which is J_2uniquely distinguished g_1from the set of $\psi\{\bullet\}$ features formed by the operator G_1. Theus, the task of identifying a technological situation is ¬considered as a multi-criteria two-stage decision-making procedure.

The convergence of the decision-making procedure is evaluated by the criterion

$$J = \Omega\{g_i^1\} - \eta \to 0 \qquad (7)$$

where the index n_1is determined by (5); $\Omega\{*\}$ - some operator

As a mapping model $\psi\{\bullet\}$ for identifying the modes of distillation processes, it is proposed to use the model for calculating the characteristic points of the

PC (PC side extractions) $t_i^a = f(R,l)$, where t_i^a t e apparat yapp drinking and % of the i -the selection, u = 10.90 "% coo corresponding to one of the selected situations, for example, M 1.

Our studies have shown that outside the area of adequacy of situational models for the processes of separation of oil c m e withe e the rectification methods, there is an unambiguous relationship between the input coordinates of the model R and T and the calculated one t_i^a . are functionally related to the measured R and T, and are also unchanged by the parameters of the set R .

Applying the procedure for restoring the ITC curve of raw materials from points calculated by M 1, you can get a lot of curves, the position of which will be determined by bothe external factors, such as the type of raw materials, and the parameters of the technological regime. At the same time, the functional relationship between the parish of the model t_i^a and the process parameters R and T is clearly traced. The resulting curve will be called the pseudo-ITC curve of the raw material r (r ", t "). The raw PTC curve is an auxiliary model designed to determine the measured parameter - the type of raw material.

On fig. I shows the pseudo-ITC curves obtained using the display model for some modes Cap corresponds to the pseudo-ITC curve for the type of raw material - a mixture of Tuymaznskaya and West Siberian low-sulfur oil 50% / 50%; (•) corresponds to the pseudo-ITC curve for the type of raw material - pure 'West Siberian sweet oil).

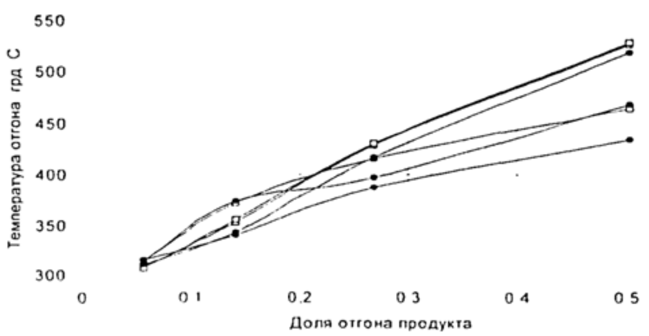

Figure 1. Pseudo-ITC curves of raw materials reconstructed from an auxiliary model

Studies have shown that for a given raw material at various operating parameters, the pseudo-ITC curves form a bundle of curves, the boundaries of which will not coincide withe the boundaries of the bundle of curves corresponding to another raw material in the sense of the J criterion. Theus, the task of identifying a technological situation through pseudo- ITC curves is equivalent to the pattern recognition problem. Moreover, the first subtask of identification of the subset G, is reduced to the beam of curves corresponding to the attribute; n_1 $n_1 \in p_1$the second subtask of identification $g_1 \in G_1$is defined as the flow of the corresponding curve in this beam.

Identifying a technological situation based on pseudo-ITC curves withe different levels of information about the unchanging process variables are considered, and various criteria for (6) and (7) are proposed. The identification procedure has the form.

Step 1. Subset G_1and situation are identified $g_1^i, g_1^i \in G_1 \left(i = l, n_c; j = l, m; n_c\right)$ - the number of subsets introduced into consideration, divided by non- measurable process parameters (situation in subset p|); m is the number of selected situations in the rank of one immutable feature).

Step 2. Restore feature η_1 by subset ρ_1 using feature properties $g_1 \in G_1$

Step 3. If the feature η_1, matches the feature defined in step I, then the subset G_1, is identified correctly. Otherwise, the situation is considered in the subset $G_1(l \neq i)$ If, after enumeration of the entire subset p, no match was found for the features identified at various stages, n_1the following options for completing the procedure are possible:

patterns are estimated on the basis of sensitivities, with the involvement of information about the "proximity" of the current regime to the selected subsets , if there are mechanisms for adapting models, additional subsets G_1G are allocated , and the corresponding models M'

The development of a feature verification procedure n_1(step 2) requires an individual -approach to individual petroleum refining processes and elements of the p3 subset . In particular, for the processes of separation of oil mixtures in distillation columns (for example, vacuum distillation of fuel oil), one of the possible options may be additional identification of the characteristics of the feedstock by curves of true boiling points. To do this, the true ITC curve of the raw material is restored according to the identified situational model M_n^k for calculating the characteristic

points of lateral withdrawals and compared with the ITC curves theta correspond to the types of oil introduced into consideration.

In the event theta the situational models for calculating the characteristic points of the ITC of lateral samplings were evaluated, it was proposed to use the following approach.

It has been established theta the pseudo-ITC curves for different types of raw materials, reconstructed from the same M 1 display model with the same measured input parameters $r \in R$ (for example, for a

vacuum column of an oil primary processing unit), have a different location relative to each other. Then the aforementioned procedure for restoring the truth of the pseudo-PTC curve can be replaced by reconstructing the pseudo-PTC curve under the same input initial conditions (base values). According to the relative position of the reconstructed and model pseudo-ITC curves, one can judge the qualitative composition of the raw material.

The procedure for bringing the pseudo-ITC curve of the current mode to the basic values of the input parameters for which the model curves are determined is considered.

Variants of using information about the degree of proximity of the current situation to these identified in the identification of the situational model and the evaluation of the values of the PC product are considered.

The process of learning situational models can be characterized as the formation of a knowledge base about the volume. At the same time, it should be taken into account that: 1) the evaluation of the parameters of the prayer houses is carried out in the mode of normal operation according to the observed data of the parameters of the technological mode of the organization of feedback on the values of the PC. obtained by laboratory; 2) the estimated parameters of the situational models are interconnected withe the procedure for identifying the technological situation; 3) estimation of model parameters can be carried out under the influence of interference on the channels for measuring technological variables, and therefore, the task is to select and adapt interference-resistant algorithms for parametric identification; algorithms for estimating model parameters should make it possible to implement them with minimal effort on the basis of industrial microcontrollers in conditions of limited computer memory resources and use the capabilities of standard libraries; 5) the use of static models for calculating the PC implies a dynamic correction of technological parameters in order to bring them to one time slice, g.e. the operation of dynamic filtering (dynamic alignment of parameters is required.

The purpose of parametric identification of situational models for calculating the PC of products is the maximum approximation of the calculated value of the model n PC values obtained in the laboratory.

Let us formulate in general terms the problem of parametric identification of situational models for calculating PC products. [1]

The task of dividing a set of technological situations into subsets and forming a matrix of coefficients of situational prayer houses is formulated as follows. When developing training procedures for situational models of PC calculation, an assumption is introduced about the invariance of the structure of models for various technological situations. As a result of the study of models of the processes of separation of oil mixtures by rectification methods, it was found theta the structure of PS models, determined phenomenological or by regression analysis methods, can be taken unchanged in a wide range of variation of attribute variables for typical objects and similar PSs.

The most acceptable option for obtaining models for estimating PC products is to use iterative methods to obtain the structure of PC models and an initial approximation model to improve the rate of convergence of algorithms, and recurrent methods for parametric adaptation of PC models under the influence of interference and the absence of a priori information about interference in observations. The recursive method of stochastic approximation is adopted as the basis for the method for identifying the parameters of the PC calculation models.

When developing training procedures for situational chapels, two possible situations are considered: 1) interference in the channels for measuring parameters is negligible; 2) interference in the channels for measuring parameters is comparable in level with the useful signal. The first assumption makes it possible to form a relatively easy-to-implement algorithm for selecting the coefficient of models for one observation. In this case, the hypothesis of the stationarity of the characteristics is accepted, i.e. the parameters on which training is carried out, measured at a discrete moment n, take the same values under the same external conditions as at the moment n-1 and d . Theism makes it possible to carry out the steps of the stochastic approximation procedure for one observation. Based on this algorithm, models of the initial approximation are formed, which allow accelerating the process of convergence of the stochastic approximation procedure when estimating the coefficients of the models under the influence of noise (by a series of observations).

The peculiarity of applying the method of stochastic approximation to the case under consideration lies in the situational nature of the model of PC products. In this regard, a separate and important task in identifying the parameters of situational models is to assign a series of current observations to the k - the situation.

The following approach is proposed for solving the problem of estimating the parameters of situational models for calculating the PC products from a series of observations.

The intervals of variation of attribute variables are divided into situational sub- intervals, taking into account the area of model adequacy.

For the k -the situation (k= 1,2,...) are given by the size of the training sample (the number of steps n in the stochastic approximation procedure).

Based on the analysis of logical expressions for the k -the situation, or using pseudo-ITC curves, the problem of assigning current technological parameters to one of the selected situations is solved.

For the k -the situation, the next (first) step of the stochastic approximation procedure evaluates the parameters of the model for calculating the PC products.

The resulting model of the k -the situation is checked for adequacy by calculating the average error in determining the values of the PC either by the training sample or by the generated test sample from the liana of the k-the situation. If the average error of the PC calculation exceeds the specified one, then the training of the model for the k -the situation continues for another n series of observations [4]

The selection of a new technological situation and a situational model for calculating the PC is carried out on the basis of the fulfillment of the condition. At the same time, new situational subranges of variation of attribute variables are determined.

An approximate relationship has been established between the error in measuring the parameters of the technological mode, the number of steps (the size of the training sample) of the stochastic approximation procedure when training the situational model, and the permissible accuracy of estimating the values of the PC of products according to the obtained models. The adequacy of the proposed solutions was tested on the developed simulation model of the vacuum column of the primary distillation unit.

The models represent the following dependencies: $t_1^a = \varphi(t_1, P), v_1 = \varphi(t_1^{10}, t_1^{90}), t_1^{ACB} = \psi(t_1^{10})$

where is the t_1^a ejection temperature $a\%$ i-th selection , t -temperate pa i-10 o selection ; P - pressure at the top of the column; v_1, - coefficient of kinematic viscosity i-10 selection: l " c " - flash point i-10 selection.

The input parameters of the models are the measured parameters of the technological mode: sampling temperatures and column top pressure. In addition, to identify the technological situation and the model for calculating the PC, information is used on the values of the flow rates of raw materials into the column and the distillation products withdrawn from the column. Models are trained on the basis of laboratory analyzes of the evaluated products.

According to the compiled training sample (8 observations), training was carried out. There situational models were identified for the considered technological situations. On fig. Figure 2 shows the change in the PC obtained from the models and in the laboratory for the modes of the training sample (13 observations).

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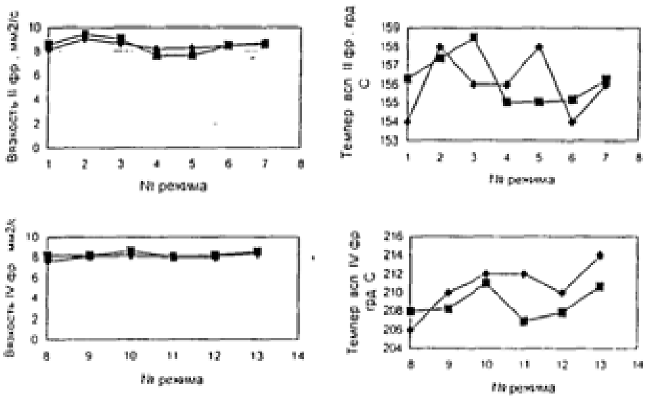

Figure 2 Change in the estimated values of PC for the modes of the training sample (♦ - corresponds to a change in the PC, determined by the laboratory, ■ - coo corresponds to a change in the PC, determined by calculation).

The average relative error estimate of the chemical viscosity of the second fraction for the modes of the training set was -4.5%, the kinematic viscosity of the fourth fraction - 3.2%, the measurement of the flash point of the second (fraction - 1.0%, The obtained situational models for calculating the PC of products make it possible, with an accuracy acceptable for operational control processes (3-5%), to evaluate the values of the PC of products of the vacuum column K-5 of the LVTm-9 installation DO PUNP'Z in the range of variation of the parameters of the technological mode of the training sample. [5]

Conclusion. For the purposes of operational management by PC, it is proposed and justified the use of a model with an unchanged structure. At the same time, the non-linearity and non-stationarity of processes are taken into account by the situational nature of the models for calculating the PC of products, identified, among other things, by non-measurable process parameters. A classification of identifiable technological situations has been carried out and a method for identifying in the space of measured variables has been developed based on the synthesis and subsequent analysis of logical expressions theta define the situation in variants of two-valued fuzzy logic. It is shown theta the proposed method provides non-discontinuous evaluation of the PC in the transition from one situation to another. The choice of criteria allowing to separate situations and identify unmeasured feature variables based on the developed method of auxiliary operators is substantiated. Algorithms for training situational models for calculating the PC in the mode of normal operation of an object have been developed, providing for both a low and a high level of interference in observations.

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