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PRIORITY EVALUATION OF MODEL BUILDING PARAMETERS AND ALGORITHM DEVELOPMENT

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ABSTRACT: *The article reviewed the development of the priority assessment algorithm, the operation of the control object, the quality and reliability of the measuring path, the quality and reliability of computer equipment and communication channels, problem solving, etc. With a solution to the problem offers an algorithm. Considering the above estimates as some generalized coordinates, we obtain an effective mathematical description of complex production processes.*
Key words: *algorithm, model, priority assessment, control cycle, flexible synthesis, low-inertia, mathematical expectations, data matrix.*

INTRODUCTION

Due to the presence of a greater number of heterogeneous disturbing influences, the control system of the SMEs will hardly support the operation of the control object with the required quality and reliability. This problem is especially aggravated for multistage production processes with continuous - discrete and continuous character, where the control cycle is limited from below by the speed, quality and reliability of the measuring path, and from above by the speed, quality and reliability of computers and communication channels.

Often, the direct determination of the values management system of process parameters in a production environment presents a certain difficulty. The complexity of solving this problem is due to the fact that existing sensors and measuring devices do not have the required reliability, they are difficult to install on a functioning facility, and their cost is high.

METHOD

In order to solve such problems, the following algorithm is proposed:

Empty there are many technological parameters

$$G = G\{x_1, x_2, \dots, x_n\},$$

consisting of two subsets:

$$G_1 = G_1\left\{x_1^{(1)}, x_2^{(1)}, \dots, x_k^{(1)}\right\}, G_1 \in G,$$

whose values are easily determined, and

$$G_2 = G_2\left\{x_1^{(2)}, x_1^{(2)}, \dots, x_s^{(2)}\right\}, G_2 \in G,$$

where values are difficult to determine.

In this case, the ratio

$$G_1 \cap G_2 = \Phi\,, \quad G = G_1 \cup G_2 uk + s = n.$$

If it is possible to determine the values of the parameters of the set G_2, then it can be used to construct a system of models with respect to those parameters whose values are determined with a large time delay and costs.

In the operator form, the system of models can be represented in the form.

$$G_2 = \varphi(G),$$

where φ is a functional operator selected from the arsenal of mathematical equations and methods that meet the requirements of specialists in solving specific problems. The system of models is laid in the computer memory and at each control cycle is used to estimate and forecast the values of difficult-to-determine parameters.

The essence of the proposed approach lies in the application of the “flexible synthesis” methodology consisting in the use of information and its organization quality at the design and implementation stage in the procedures for developing control actions in control cycles at the design and implementation stage of experimental data on the dynamics of the production process.

For a more detailed analysis of the proposed algorithm, we assume that there is a matrix of experimental data X_0 of dimension $(n \times m)$taken for (t_0, t_1)time interval, whose elements are x_{ij}, $i = \overline{1,n}$; $j = \overline{1,m}$;are input variables including control variables and output variables. At the same time j means the number. Between these variables is the ratio.

$$Y = F(x, u)\,, \qquad (1.1).$$

where x - values of state variables among, u - state of control variables, Y - output values of state variables, F - conversion operator.

We introduce the vector $\widehat{x_j} = \{x_{1j},\ x_{2j}, \dots, x_{nj}\}$which determines the set of measured values $\widehat{x_o}$can be represented as a set of columns $\widehat{x_j}$, $j = \overline{1,m}$ ..

Based on the collected statistics of the experimental data $\widehat{x_o}$a correlation matrix $\mathscr{R}$ is constructed and the analysis is performed on the strength of the correlation connection (the relationship between variables at $0 \le \mathscr{R}_{ij} \le 0.3$ for $\forall_i$, $j = \overline{1,m}$, $i \neq j$weak, at $0.3 \le \mathscr{R}_{ij} \le 0.7$- medium and $0.7 \le \mathscr{R}_{ij} \le 1.0$ strong), the results of which reduce the dimension of the description of the production process to $\widehat{x_o^{'}}$.

Thus, as a result of this procedure, a subset $\widehat{x_j}$ is allocated with the $\mathscr{R}_{ij} \le 0.7$ matrix $\widehat{x_o}$ takes the form $\widehat{x_o^{'}}$with the dimension $[n \times l]$, $(l \le m)$and by analogy with (1.1) we have.

$$Y = F_1\left(\widehat{x^1}\,, U\right). \qquad (1.2)$$

Simultaneously with the above systematization of experimental data statistics in order to improve the quality of operational control at each step of the control cycle, the remaining set $\widehat{x_j}$ and $\widehat{x_o^{'}}$ is classified into low-inertia (usually bistro-definable) $\widehat{x_j^{'}}$ and strongly inertial variables $\widehat{x_j^{''}}$, and in order to further reduce the dimension of the task of describing the state of the production process, the relationship between them is established (determined).

$$\widehat{x_j^{''}} = \varphi_{j-s}\left(\widehat{x_1^{'}}, \widehat{x_2^{'}}, \dots, \widehat{x_s^{'}}\right)\,, j = \overline{s+1}, l. \qquad (1.3)$$

Systematization in this case is carried out according to the following algorithm. Empty in the matrix $\widehat{x_o^{'}}$ the vectors $\widehat{x_j^{'}}$ are grouped in such a way that the first are located at the beginning with the vector $\widehat{x_j^{'}}$, $j = \overline{s,1}$,the corresponding low-inertia variables, and then the vectors $\widehat{x_j^{''}}$, $j = \overline{s+1}, l$,corresponding to strongly inertial variables in real time.

As a result, the data matrix $\widehat{x_o^{'}}$is represented as two submatrices - $\widehat{x_o^{''}}$ is low-inertia and - $\widehat{x_o^{'''}}$ is strongly inertial.

When choosing the methodology of mathematical methods for determining the structure φ_{j-s} , $j = \overline{s+1}, l$, special attention will be paid to the method of the modeling function.

In the paper, as a proximity to the evaluation of the object operator, the criterion of the minimum of a quadratic functional of the form is applied to its true value:

$$R_{\kappa p} = m_E + \sum_{i=1}^{n} \xi_i \, \kappa_E(\tau_i), \qquad (1.4)$$

where $\kappa_E(\tau_i)$ is the value of the correlation error function at the time τ_i, ξ_i, i are some constant coefficients that satisfy the condition $\sum_{i=1}^{n} \xi_i^2 \neq 0$.Then the optimal estimate of the object operator can be searched for in the class of linear integral stationary operators.

$$Y(t) = AX(t) = \int_{-\infty}^{t} \omega(\tau) x(t-\tau) d\tau,$$

where ω (t) is the weight function of operator A.

Further, expressing the functional (1.4) through the original statistical data and taking into account the physical realizability of the system ($\omega(\tau) = 0$,, with $\tau < 0,\ \tau > t$, we obtain

$$\begin{aligned} R_{\kappa p} \ &= m_x \int_0^T \omega(\tau) d\tau - m_y \\ &+ \sum_{i=1}^{n} \xi_i \left[\iint_{00}^{TT} \mathrm{K}_x \cdot (\tau_i - \lambda + \tau) \omega(\tau) d\tau d\lambda \right. \\ &\left. - 2 \int_0^T \mathrm{K}_{xy}(\tau_i + \tau) \omega(\tau) d\tau + \mathrm{K}_y(\tau_i) \right], \qquad (1.5) \end{aligned}$$

where $m_x,\ m_y$is the mathematical expectation of the input and output signals; $\mathrm{K}_x(\cdot)$и$\mathrm{K}_{xy}(\cdot)$ are auto and the cross-correlation function of random processes x(t) and y(t). respectively. Expression (1.5) is a functional of the weight function of a type model.

$$R_{\kappa p} = \iint_{00}^{TT} \Phi[t, s, \omega(t), \omega(s)] dt ds.$$

The integrand in this case has the form.

$$\begin{aligned} &\Phi\big(\tau, \lambda, \omega(\tau), \omega(\lambda)\big) \\ &= \sum_{i=1}^{n} \xi_i \mathrm{K}_x(\tau_i - \lambda + \tau) \omega(\tau) \omega(\lambda) \\ &- \frac{1}{T} \sum_{i=1}^{n} \xi_i \big[\mathrm{K}_{xy}(\tau_i + \tau) \omega(\tau) + \mathrm{K}_{xy}(\tau_i + \lambda) \omega(\tau)\big] + \frac{m_x}{2T} [\omega(\tau) + \omega(\lambda)] \end{aligned}$$

and is a symmetric bilinear form with respect to $\omega(\tau)$and$\omega(\lambda)$.

It is easy to show that the estimate of the weight function of the object must satisfy the linear Fredholm integral equation of the first kind.

$$\int_0^T \sum_{i=1}^{n} \xi_i \mathrm{K}_x(\tau_i - \lambda + \tau) \omega_0(\lambda) d\lambda - \sum_{i=1}^{n} \xi_i \mathrm{K}_{xy}(\tau_i + \tau) + \frac{m_x}{2} = 0\,,$$

where $\omega_0(\lambda)$is the optimal estimate of the weight function of the object by the criterion (3.10). The solution to this equation can be found using the methods outlined.

Considering the above estimates as some generalized coordinates, we obtain an effective mathematical description of complex production processes.

The result of the above systematization $\widehat{x_o'}$ allows them to be used to improve the efficiency and quality of the decision-making procedure in the ICP management cycles for the information on the values $\widehat{x_j}$.

The efficiency of the decision-making procedure in the control loop can be hung due to further systematization and ranking of the elements of the sub matrix$\widehat{x_o''}$. For this purpose, the elements of the matrix $\widehat{x_o'}$are divided into controllable and uncontrollable (but controllable) parameters with their further ranking on submatrices of lower dimension in the following way.

We introduce the set $J_1 = \{j\}$, consisting of numbers of unmanaged variables. In accordance with the above procedure, using the values of the correlation matrix R_{ij} , the elements of the set $J_1$are ordered. For this purpose, the interval $(a_0\ , a_d)$on the basis of technological considerations or the distribution law (normal, beta distribution, etc.) is divided into d under the intervals $[a_0 a_1)\ , [a_1 a_2)\ , \ldots , [a_{d-1} a_d)$.

Then, from the subset J_I the first one is taken, for example, with the order number I with the value of possible ego values on the interval $[a_0 a_d]$.

The ordering procedure $\widehat{x_k'}$ in the subset J_1consists in grouping under the intervals and is determined by the membership $\widehat{x_k'}$of the corresponding sub intervals. The whole set $\widehat{x_k'}$in each of the above-mentioned intervals forms, respectively, subsets $I_1, I_2, \ldots , I_d$.. In accordance with the selected sets $I_1, I_2, \ldots , I_d$., the rows in the matrix $\widehat{x_0'}$are rearranged in such a way that all values of the vector $\widehat{x_j'}$in under the interval $\widehat{x_k'} \in [a_0 a_1)$), stood at the beginning (at the top) of the matrix, then $\widehat{x_k'} \in [a_0 a_1)$, etc.

Thus, the initial data matrix $\widehat{x_k'}$ by the values of one of the elements of the subset $J_1$is represented in the form of several submatrices of significantly smaller dimension.

Further, for all rows with the sequence number $i \in I_\alpha, \alpha = \overline{1, d}$the corresponding model (1.2) is constructed with respect to some pre-selected output indicator of the process. For example, an empty variable with a sequence number q is an output indicator $\widehat{x_q'}$. Then the model (1.2) takes the form:

$$\widehat{x_{q_1}'} = f_1\left(\widehat{x_1'}, \widehat{x_2'}, \ldots , \widehat{x_k'}, \ldots , \widehat{x_{q-1}'}, \widehat{x_{q+1}'}, \ldots , \widehat{x_s'}, \widehat{x_{s+1}'}, \ldots \widehat{x_l''}\right) \quad \text{for } \widehat{x_k'} \in [a_0 a_1),$$
$$\widehat{x_{q_2}'} = f_2\left(\widehat{x_1'}, \widehat{x_2'}, \ldots , \widehat{x_k'}, \ldots , \widehat{x_{q-1}'}, \widehat{x_{q+1}'}, \ldots , \widehat{x_s'}, \widehat{x_{s+1}'}, \ldots \widehat{x_l''}\right) \quad \text{for } \widehat{x_k'} \in [a_1 a_2),$$
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$$\widehat{x_{q_d}'} = f_d\left(\widehat{x_1'}, \widehat{x_2'}, \ldots , \widehat{x_k'}, \ldots , \widehat{x_{q-1}'}, \widehat{x_{q+1}'}, \ldots , \widehat{x_s'}, \widehat{x_{s+1}'}, \ldots \widehat{x_l''}\right) \quad \text{for } \widehat{x_k'} \in [a_{d-1} a_d).$$

An important advantage of the proposed approach to the organization of information conversion processing technology is that the constructed models of the form (1.4) can also be used to predict the characteristics of an object's output indicator and to control them in the future under real production conditions.

RESULTS

The essence of the proposed algorithm for choosing the preferred process model with regard to technological situations is as follows. If the values of the variables of the object with the number $j,\ j = \overline{1, s}$ determining on the P - th control cycle, then by substituting their values into (1.4), respectively, each model with different accuracy determines the values of the output indicator. In this case, the substitution of the values of these variables in a model of type (1.4) is carried out taking into account their membership in the sub interval $(a_{r-1}\ , a_r)$. In this case, the error between the measured and calculated by the model value of the output indicator is determined as follows

$$\delta_r = \left|\widehat{x_{q_r}^{'p}} - f_r\left(\widehat{x_I^{'p}}, \ldots , \widehat{x_k^{'p}}, \ldots , \widehat{x_q^{'p}}\widehat{x_{q+1}^{'p}}, \ldots , \widehat{x_s^{'p}}\widehat{x_{s+1}^{''p}}, \ldots , \widehat{x_l^{''p}}\right)\right|$$

at$\widehat{x_k^{'p}} \in (a_{r-1}\ , a_r)$, where $I \le r \le d$.

However, there may be cases when the selected model does not approximate the statistical dependence in a real process with satisfactory accuracy.

Empty ξ_β - some given accuracy of the desired model. If $\delta_r < \xi_\beta$, then the selected bit model is used to solve subsequent optimization and control problems; otherwise, $\delta_r > \xi_\beta$, adaptation is necessary.

One of the possible ways to improve the accuracy of models (1.3), (1.4) is to adjust them based on the accumulation of statistics during operation.

Thus, the practical implementation of all stages of the above methodology for selecting the most appropriate structure (type) of the process model, will significantly reduce the computer computer memory and machine time spent on processing a large amount of information, and increase the reliability of the model. Consequently, the use of reliable models in the normal operation of the control object leads to a significant reduction in valuable material and energy resources and thereby improves the quality of management.

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