УДК 681.513.8

COORDINATION OF TECHNOLOGICAL COMPLEX (TC) SUBSYSTEMS OF SUGAR MILL CONSIDERING THE DOUBTFUL INFORMATION

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Abstract. *The paper considers an approach to setting the extended task of the coordination in technological complex of continuous type. In particular technological complex of the sugar mill is considered. The main features of the solution of the coordination problem are described.*

Keywords: *principles of coordination, subsystem of technological complex, fuzzy knowledge, time series, the function purpose.*

Introduction. Technological complex of sugar mill in terms of control problems is notable for its multidimensional, the presence of certain stages of processing raw materials and intermediates, and complex ties between the stages, which are realized in technological equipment of large unit capacity. The automation of individual parts of TC (districts, sub-systems) makes it impossible to achieve high technical and economic performance of the TC as a whole, because they depend largely on the mutual ties between the subsystems of TC that objectively leads to the need for developing the coordination problem of controlled subsystems.

Research methods. The decomposition method is used to construct the management structure that allows us to consider TC as a set of subsystems. In terms of management problems there is the optimal number of subsystems within the TC [1]. To solve the coordination problem the interaction between subsystems, in which management optimized for each of the subsystems is also optimal for a general criterion for the TC as a whole, must be determined.

Coordination is a specific problem of hierarchical control system and currently uses a number of principles [2], on which iterative and non-iterative procedures of the problem solution are based: prediction of interactions where coordination is done by setting variables of interactive coordinated subsystems (this corresponds to an intermediate objective); coordination interactions, which provides local functions modification using objective parameters that are set by coordinator (this corresponds to an intermediate price); evaluation of interactions, which can be viewed as a generalization of the principle of interactions prediction in the case when the region of admissible values of variables of interaction subsystems are set by coordinator in subtasks of the lower level.

Complicated management system consists of various elements - control centers resulted from horizontal and vertical distribution functions. In multilevel hierarchical management systems the decisions of harmonization and coordination tasks are taken at all levels of management. The most famous two-level management structure of TC [3].

Considering the complexity of TC sugar mill, it is advisable to consider the extended two-task coordination, where overall or global problem is solved at subsystems level and local or internal problem - coordination at the level of individual subsystems.

In Fig.1 Using a Data Flow Diagram (DFD) shows a complex hierarchical structure of TC sugar mill, for which the problem of global coordination should be considered as approval of the major branches (diffusion, juice refining, evaporation), and the problem of local coordination - coordination of relevant departments. For example, the juice refining department subsystems coordination to address the problem of local coordination is the first defecation, defecation, I, II saturation, sulfation; each of these processes has its own optimization problem.

For setting the problem of coordination is necessary to analyze the investigated TC (for example, using DFD), select the subsystem to form a complex on the basis of selected subsystems.

To resolve the problem of coordination of the complex objects, especially technological complexes (TC), there is always the problem of evaluation of their condition, which caused a continuous change as the environment and parameters of the object.

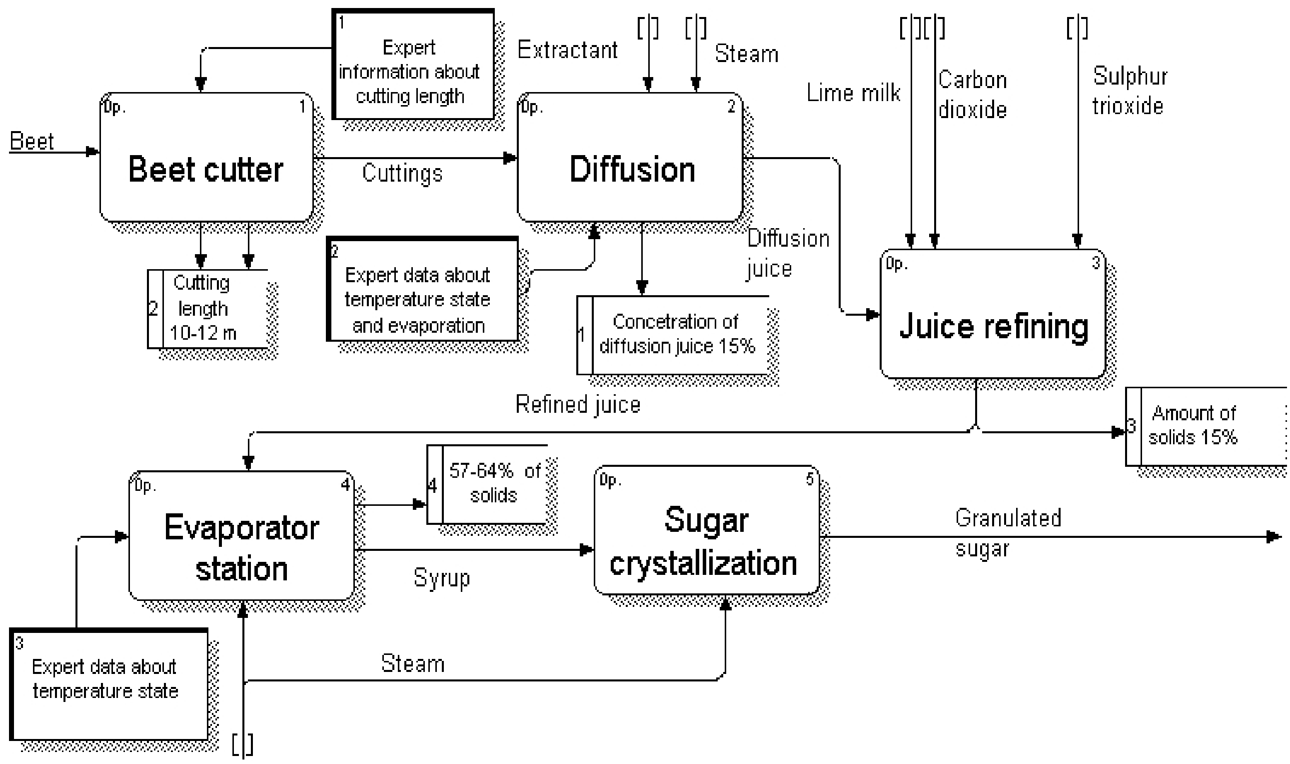

Fig.1. The structure of the technological complex (TC) of the sugar mill

Thus, the control objects are dynamic, to describe their status using dynamic models - both deterministic and stochastic. Methods of analysis of dynamics of complex dynamic objects include: deterministic, statistical, probabilistic, logic, neural networks and fuzzy models [4].

Results and discussion. Particular attention is paid to the reception and processing of knowledge related to the so-called non-factors, i.e. uncertainty, inaccurate, unclear [5]. Such knowledge is given a tuple [6]:

$$З_{не} = (З_1, З_2, З_3), \tag{1}$$

which used the combined methods of getting from experts in problem-oriented texts in natural language and databases. Fuzzy knowledge of uncertainty are based on procedures that provide for the definition of reliability coefficients in the interval [0,1] and may be outside [a; b] to [0,1]. In terms of the refinery to such knowledge are: sugar beets, sugar output at a certain time interval, the prices of raw materials, energy and finished products, etc.. Knowledge $З_2$ related to inaccuracies, which are characterized by numerical values obtained primarily from instrumentation certain accuracy. This is the first technological variables: temperature, level, pressure, etc. costs. Knowledge $З_3$ of linguistic variables characterized by certain membership functions and fuzzy linguistic terms ("high", "low", "medium").

A well-known method of describing the knowledge of uncertainty is the model of knowledge representation with uncertainty factors that meet the statement appearing in the reference and the consequences of the rules to reflect the patterns in problem areas. For example, Bayes and Dempster- Schafer methods are used when the parameters attributed to a factor of uncertainty.

The Dempster-Shafer method is used, when a procedure $З_1$ variable values or facts attributed to the interval, i.e. two factor uncertainties (confidence n and opportunity p). When the combined interval uncertainty of claims H based on two rules $E_1 \rightarrow H$ and $E_2 \rightarrow H$, which gives ratings $[n_1, p_1]$ and $[n_2, p_2]$ has boundaries [6]:

$$n = \frac{n_1 p_2 + n_2 p_1 - n_1 n_2}{1 - n_1(1 - p_2) - n_2(1 - p_1)}; \; p = \frac{p_1 p_2}{1 - (1 - p_2) - n_2(1 - p_1)} \tag{2}$$

At the Dempstera-Sheyfera method coefficients confidence and capabilities are treated solely as a subjective evaluation of both the expert and can take values "unit" for accurate statements is not required in the knowledge base, but rules bring information on the a priori probability events.

Upon receipt of inaccurate data from sensors and instrumentation, inaccuracy of numerical values estimated coefficient in the interval [0, 1], and the results of calculation by the formulas for determining the absolute errors on the basis of the differential complex functions $z = f(x, y)$:

$$\Delta f(x, y) = \left| \frac{\partial f(x, y)}{\partial x} \right| \Delta x + \frac{\partial f(x, y)}{\partial x} \Delta y, \tag{3}$$

$$\varepsilon(x,y)=\frac{\Delta f(x,y)}{f(x,y)}$$

Finally, knowledge $З_3$ of the main task is to determine the functions of fuzzy linguistic terms and their description. For a particular subject area appropriate to create a dictionary of natural language terms that are often used in this system, such assessment amounts. Membership functions are given as piecewise-linear dependencies in a set of pairs of points $(x_i, \mu(x_i)), i=\{1,...n\}, x_i$ – the element of fuzzy sets; μ – membership function. In a knowledge of the function of belonging: $\mu=0$ interpreted as false; $\mu=1$ – truth; $\mu=0{,}5$ – full of uncertainty.

In the technical literature to determine the set of states of operation of dynamic object different approaches is used: a subset of phase space with certain properties (constraints) segment of time series, generalized description of the features of the phase trajectories [7]. Thus, recognition of states of complex dynamic objects requires the use of modern methods, especially the development of intelligent information models based on information in the form of time series which can be stationary with non-linear trend.

Each subsystem is formed by objective function $\varphi_i(U_i, X_i)$, wherein U_i – management actions, X_i – coordinates of (output variables) of the subsystems. To find the functions, you need to know the purpose of appropriate management and coordinates of an object. The evaluation of complex dynamic objects can be made based on time series analysis - statistical estimators and random signals. Random process is set in a manner which characterizes the state of the object:

$$\{X,Y\}=\{X(t),Y(t),t_1\le t\le t_2\}, Y(t)=f(x(t),\zeta(t)) \quad (4)$$

where: X – vector of state variables of the object, which is not observed; $Y(t)$ – random vector function that is observed (may be $Y(t)=X(t)$); $\zeta(t)$ – noise (interference) rather general nature of the limited dispersion. Accepted that the time sample of a random process can be defined in one of the expert or the training sample areas (classes) $\Omega_1, i=\overline{1,I}$. It highlighted $I>1$ alternative hypotheses $\Omega=\{\Omega_1,\Omega_2,...,\Omega_i\}$, characterizing the full group of events and are interpreted as classes of object. In the real object or model observed random process in discrete time points, $t\in\{t_0,t_1,...,t_N\}, t_j=t_0=j\Delta; j=\overline{0,N}$. Δ - sampling interval, $\Delta>0$. Then the value of $Y(t)$ on the interval $[t_1,t_2]$, belongs to a class $\Omega_1, i=\overline{1,I}$.

To determine the appropriate use of an object control cards, because their analysis is interpreted as:

- signal that the process took some change;
- as an estimation of changes to address any necessary corrective action;

- to determine the number of evaluations of similar cases in the past and determination on the basis of reasons that caused these changes;
- as a measure of quality for the classification of the periods [8].

For each of the subsystems TC formed the goal function, which takes into account the input and output variables, and also the state of the object [9]:

Then the general problem of optimal control of TC as a set of subsystems of additive convolution would be written as:

$$\max\left(\sum \varphi_i(U_i, X_i)\right) = \max \varphi(U, X) \quad (5)$$
$$\{U_i, X_i\}, i = \overline{1, N}$$

where N - number of subsystems.

The general problem of optimal control TC may take another look, depending on the choice of a global criterion. Often, as a global criterion used - additive, multiplicative and minima criteria.

The basic principles of coordination with regard coordination and compatibility of subtasks.

When the solution of general problems of the TC is existed, there are also solutions of subproblems optimal control subsystems and coordination of its work.

Another condition is the correctness of the general tasks and subtasks in hierarchical control system. The problem of solving undertake repeatedly in real time, so crucial are the following requirements: a high probability (frequency) of finding the global optimum for optimization of subsystems, high speed of convergence to the optimal solution, the ability to start work on points that lie outside the acceptable area.

To find the optimal solution in determining the modes of the subsystems recommended a modified method of boxing and simplex Neldera-Mead method, for finding a global criterion - reduced gradient method [6].

Conclusions. Based on system analysis using the methods of decomposition of selected subsystem TC sugar mill with its subtasks optimization subproblems formulated and coordination of these subsystems including false information, which previously handled Bayes and Dempster-Shafer methods. Some process variables processed by membership functions for fuzzy linguistic terms ("high", "low", and "medium").

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Author's Review

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КООРДИНАЦІЯ ПІДСИСТЕМ ТЕХНОЛОГІЧНОГО КОМПЛЕКСУ (ТК) ЦУКРОВОГО ЗАВОДУ З УРАХУВАННЯМ НЕДОСТОВІРНОЇ ІНФОРМАЦІЇ

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Анотація. *В статті розглядається підхід до постановки розширеної задачі координації в технологічних комплексах неперервного типу. Зокрема розглядається складний технологічний комплекс цукрового заводу. Описані основні особливості вирішення поставленої задачі координації.*

Ключові слова: *принципи координації, підсистеми технологічного комплексу, нечіткі знання, часові ряди, функція мети.*

КООРДИНАЦИЯ ПОДСИСТЕМ ТЕХНОЛОГИЧЕСКОГО КОМПЛЕКСА (ТК) САХАРНОГО ЗАВОДА С УЧЕТОМ НЕДОСТОВЕРНОЙ ИНФОРМАЦИЯ

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В статье рассматривается подход к постановке расширенной задачи координации в технологических комплексах непрерывного типа. В частности рассматривается сложный технологический комплекс сахарного завода. Описаны основные особенности решения поставленной задачи координации.

Ключевые слова: *принципы координации, подсистемы технологического комплекса, нечеткие знания, временные ряды, функция цели.*