МОДЕЛЮВАННЯ ТА ОПТИМІЗАЦІЯ ПРОЦЕСІВ РОЗРОБКИ ХАРЧОВИХ ПРОДУКТІВ ТА ОБЛАДНАННЯ ХАРЧОВОЇ ПРОМИСЛОВОСТІ

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PARAMETRICAL SIMULATUIN OF FUNCTIONAL CAPACITY OF THE MANIPULATOR IN A MODE OF IMMEDIATE AUTOMATED MANAGEMENT

Objective. *The purpose of article lies in ensuring the functional capacity of the manipulator. The goal is reached at the expense of increase of effectiveness of an automated control system by technological process. This effectiveness has to be provided in the course of creation and realization of expeditious operating influence in a mode of immediate automated management the quick managing director.*

Methods. *In the course of carrying out research the method of parametrical simulation is used. It uses the provision of discrete mathematics. Being guided by provisions of the formal logic the description of the scheme of formation of parameters of the functional capacity of the manipulator in transient phenomenon in a mode of immediate automated management was submitted. Using provisions of the graph theory the generalized coherent graph was contracted. The decision of this graph with use Rosenberg-Karnopp's transformation and Kelly – Richardson's theorem gave the chance to receive corrective function of the quick managing director of an automated control system.*

Results. *On the basis of the conducted research parametrical simulation of the functional capacity of the manipulator in a mode of immediate automated management is executed. The comparative analysis of results of operation of an automated control system for technological process with the reference and corrected generalized function of operating influence in a mode of immediate automated management showed that at the corrected function of operating influence decrease in mistake on accuracy of positioning for 42,9% reached.*

Academic novelty*. The parametrical model of the functional capacity of the manipulator in a mode of immediate automated management is developed. Feature of model lies in possibility of the description of the functional capacity of functioning of the manipulator in a transient regime in the course of creation and realization of the quick managing director of influence. Parametrical simulation of the functional capacity of the manipulator in a mode of immediate automated management is executed.*

Practical importance. *The received results are directed on ensuring the functional capacity of the manipulator in the course of creation and realization of expeditious operating influence in a mode of immediate automated management.*

Key words: *manipulator, parametrical model, functional capacity, coherent graph, transient phenomenon.*

Stating the problem. There are problem statements in a general view and communication with the major scientific or practical tasks. For process of function of the manipulator it is characteristic instability of its dynamics and kinematics parameters in the course of the movement of a processed product. Generally manipulator functioning it is reduced to an inequality of regional conditions of interaction of executive body of the manipulator and moved product. It is bound to feature of creation of a production cycle of the manipulator. This cycle has discrete reversible construction. At realization «start up stop» and reverse take place the transient phenomenon in manipulator structure elements. This process distorts the managing director's influence of an automated control system of technological process. Instability of the functional capacity of the manipulator in a mode of immediate automated management by technological process of movement product is as result.

Analysis of the last researches and publications. In [1; 2] possibility of a prime to complete description of operating influence of an automated control system by technological process in real time is offered. Authors used provisions of the graph theory. It allows describing process with the considerable probability of random factors [1].

It is especially efficient at realization of operating influence of an automated control system by technological process in a mode of immediate automated management [2]. How ere authors ignore the transient phenomenon at realization of the managing director of influence of an automated control system by technological process.

In [3-5] features of application of the graph theory for technological process and equipment of discrete action are formulated. In [3] application of the coherent graph for objects and processes at determination of compliance of ponder ability of separator elements of target function of influence of an automated control system by technological process is recommended. Questions of transformation of the coherent graph at research of the oscillating character are expended in [4]. Authors [5] for receiving analytic function of transformation of the coherent graph recommended using methods of the formal logic. Unfortunately the provided data have common character and cannot be used without express adaptation.

In [6-8] results of application of the coherent graph for research of transient phenomenon of oscillating character are given in branched loop system. In [6] results of simulation with use of a method of counts for multi mass line system are given. In [7] analytical dependence is received and results of the analysis of transient phenomenon for the elementary branched system are given. In [8] the transient phenomenon for the line system with power short circuit is investigated. As a whole authors were beyond determination of parameters of transient phenomenon. However they concentrated on the elementary option when external indignation of a stationary value pretends to be instantly.

In [9; 10] results of transient phenomenon simulation are given in interpretation with parameters of a processed product with use of the coherent graph. In [9] analytical dependence of transformation in the form of compound fraction is received. However there are no data on cost with test data. In [10] parameters transient phenomenon are determined and their comparative analysis with actual data is given. The result does not contain analytical dependences for use by an automated control system by technological process.

Thus, a research objective is determination of the functional capacity of the manipulator. The goal is reached at the expense of increase of effectiveness of an automated control system by technological process. This effectiveness has to be provided in the course of creation and realization of expeditious operating influence in a mode of immediate automated management the quick managing director.

The functional capacity of the manipulator in a general view is formed as result (look figure 1)

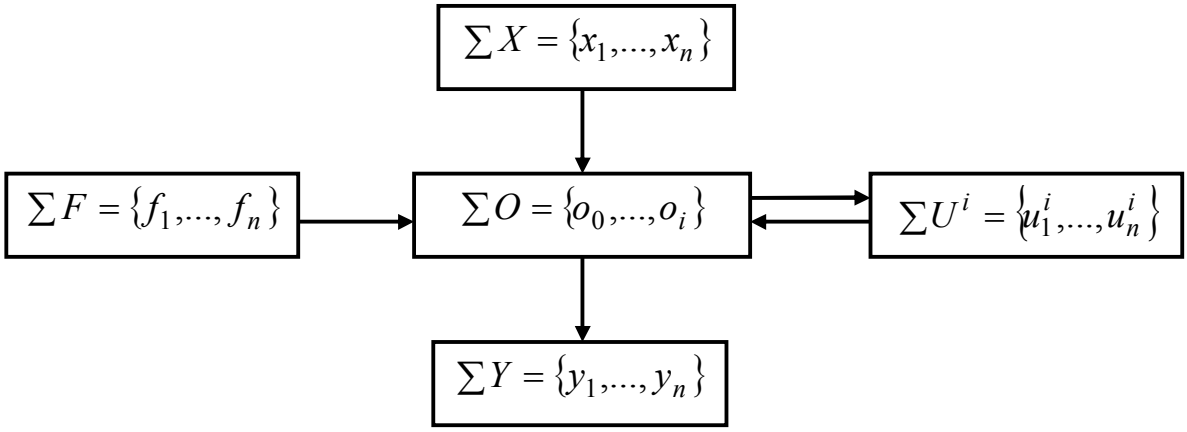

Figure 1 – The scheme of formation of parameters of the functional capacity of the manipulator

$\sum Y = \{y_1,...,y_n\}$ – concrete parameters of the executive body of the manipulator;

$\sum X = \{x_1,...,x_n\}$ – concrete parameters of a product prior to movement process;

$\sum F = \{f_1,...,f_n\}$ – concrete technological parameters according to realized operating influence of an automated control system by technological process in a mode immediate automated management;

$\sum O = \{o_0,...,o_i\}$ – the unique terminating of positioning of a product in when moving, where $i \geq 0$ – quantity of positions of movement ($i = 0$ – prior to movement, $i \geq 1$ – immediately in the course of movement);

$\sum U^i = \{u_1^i,...,u_n^i\}$ – concrete parameters of transient phenomenon at development and realized of operating influence of an automated control system by technological process in a mode of immediate automated management;

$n \geq 1$ – quantity of weighable factors.

According to the scheme (figure 1) the functional capacity of the manipulator is fully characterized by accuracy of position of a moved product $\sum E_n^i$ at the concrete moment of technological process**.** Thus it important to know concrete character of kinematical and dynamical parameters of transient phenomenon in stage «start up stop». For the concrete component of n these parameters are uniquely determinate by concrete parameters of technological process $\sum F_n$ in the conditions of their distortion by transient phenomenon $\sum U_n^i$. Then it is easy to present parametrical model of the functional capacity of manipulator in a look

$$\sum X \Rightarrow \sum O_{d\,n}{}^{i} = \begin{cases} \sum E_n{}^{i^{inv}} \underset{\Leftrightarrow}{\overset{\Leftrightarrow \sum U_n{}^{i^{inv}} \Leftrightarrow}{}} \sum F_n{}^{inv} \Leftrightarrow \\ \sum E_n{}^{i^{const}} \underset{\Leftrightarrow}{\overset{\Leftrightarrow \sum U_n{}^{i^{const}}}{\Rightarrow}} \Leftrightarrow \sum F_n{}^{const} \Leftrightarrow \end{cases} \begin{cases} \sum X^i \\ \\ \sum Y^i \end{cases} \Rightarrow \sum Y, \qquad (1)$$

where *inv* – padding components of the manipulator which are instantly formed at start-up from the beginning of technological process;

const – manipulator components which do not depended form technological process and are available irrespective of a stage «start up stop».

According to parametrical model functional capacity of the manipulator (1) function of operating influence of a control system by technological process at transient phenomenon of immediate automated management can be present in form of a transformation

$$f\left({}^{n}W\right) = \begin{cases} \begin{cases} \sum E_n^{i\,inv} - \sum\left(\sum X_n^{i\,inv} + \sum U_n^{i\,inv}\right); \\ \sum U_n^{i\,inv} - \sum\left(\sum E_n^{i\,inv} + \sum F_n^{i\,inv}\right); \end{cases} \\ \begin{cases} \sum E_n^{i\,const} - \sum\left(\sum X_n^{i\,const} + \sum U_n^{i\,const}\right); \\ \sum U_n^{i\,const} - \sum\left(\sum E_n^{i\,const} + \sum F_n^{i\,const}\right), \end{cases} \end{cases} \qquad (2)$$

According to (2) for the manipulator in a transient phenomenon of immediate automated management it is possible to construct generalized coherent graph of the functional capacity. This graph is presented in figure 2.

Respectively for this graph using Rosenberg-Karnopp′s transformation and Kelly-Richardson's theorem it easy to receive the corrected generalized function of operating influence of an automated control system for technological process in a

mode of immediate automated management taking into account description of the functional capacity of the manipulator at a transient phenomenon (3).

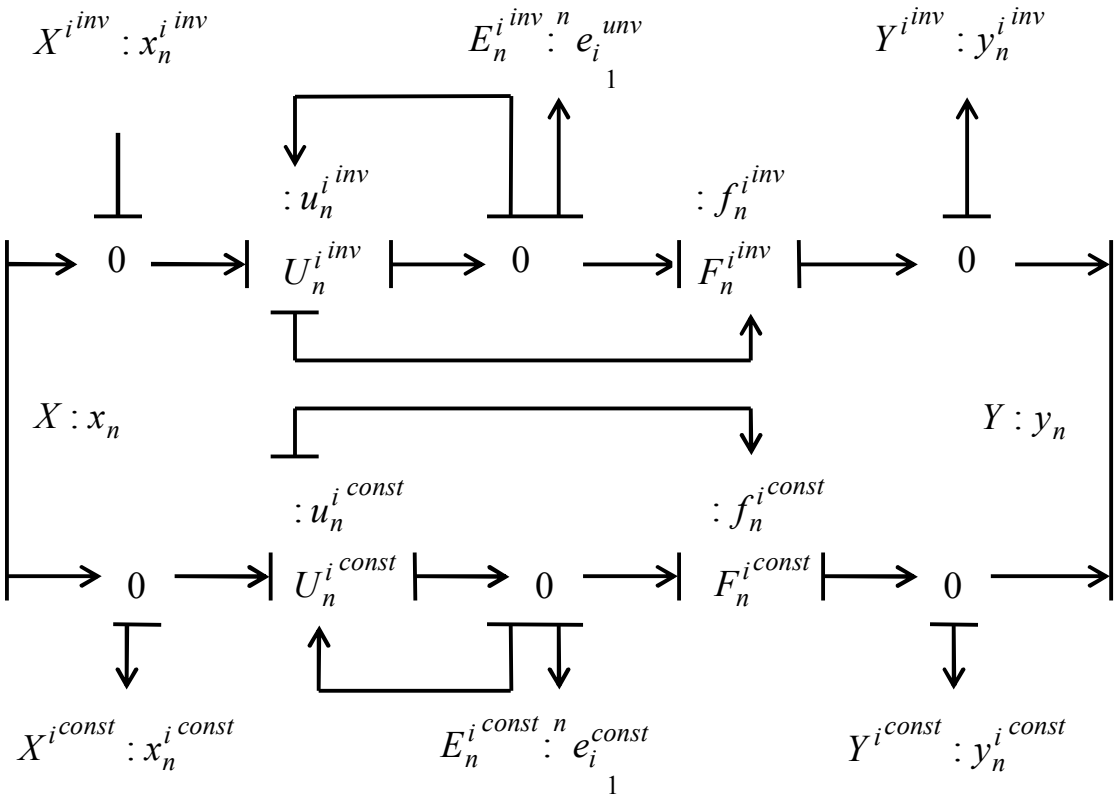

Figure 2 – The generalized coherent graph of functional capacity of the manipulator

$$f\left({}^{n}W\right)=\begin{cases}\sum\left(E_n^{i\,inv}\left({}^{n}_{1}e_i^{inv}\right)\dfrac{E_n^{5^{inv}}\left({}^{n}_{1}e_i^{inv}\right)-nE_n^{1^{inv}}\left({}^{n}_{1}e_1^{inv}\right)}{E_n^{1^{inv}}\left({}^{n}_{1}e_1^{inv}\right)-nE_n^{5^{inv}}\left({}^{n}_{1}e_5^{inv}\right)}\right)-\left(x_n^{i\,inv}+u_n^{i\,inv}\right);\\ u_n^{i\,inv}-\left(\sum\left(E_n^{i\,inv}\left({}^{n}_{1}e_i^{inv}\right)\dfrac{E_n^{5^{inv}}\left({}^{n}_{1}e_i^{inv}\right)-nE_n^{1^{inv}}\left({}^{n}_{1}e_1^{inv}\right)}{E_n^{1^{inv}}\left({}^{n}_{1}e_1^{inv}\right)-nE_n^{5^{inv}}\left({}^{n}_{1}e_5^{inv}\right)}\right)+f_n^{i\,inv}\right);\\ \sum\left(E_n^{i\,const}\left({}^{n}_{1}e_i^{const}\right)\dfrac{E_n^{5^{const}}\left({}^{n}_{1}e_i^{const}\right)-nE_n^{1^{const}}\left({}^{n}_{1}e_1^{const}\right)}{E_n^{1^{const}}\left({}^{n}_{1}e_1^{const}\right)-nE_n^{5^{const}}\left({}^{n}_{1}e_5^{const}\right)}\right)-\left(x_n^{i\,const}+u_n^{i\,const}\right);\\ u_n^{i\,const}-\left(\sum\left(E_n^{i\,const}\left({}^{n}_{1}e_i^{const}\right)\dfrac{E_n^{5^{const}}\left({}^{n}_{1}e_i^{const}\right)-nE_n^{1^{const}}\left({}^{n}_{1}e_1^{const}\right)}{E_n^{1^{const}}\left({}^{n}_{1}e_1^{const}\right)-nE_n^{5^{const}}\left({}^{n}_{1}e_5^{const}\right)}\right)+f_n^{i\,const}\right),\end{cases}\tag{3}$$

Comparison of results of operation of an automated control system by technological process with the reference and corrected (3) function of operating influence in a mode of immediate automated management $f\left({}^{n}W\right)$ showed interesting results. When using the corrected function of operating influence mistake decrease on accuracy of positioning of executive body of the manipulator for 42,9% was reached at an error of the kinematical parameters of 5,8% and time of attenuation dynamic oscillating process 17,2%.

Deduction. Correction of the generalized function of operating influence of an automated control system by technological process for the manipulator in a mode of immediate automated management does possible effectiveness increase in respect of increase in accuracy of positioning of executive body of the manipulator.

Practical significance. The received results are directed on ensuring the functional capacity of the manipulator in the course of creation and realization of expeditious operating influence in a mode of immediate automated management. These results create the actual level of influence for ensuring body height of accuracy of position of executive body of the manipulator in a mode of immediate automated management of an automated control system for technological process without cardinal change of its elements base.

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Цель. *Цель статьи заключается в обеспечении функциональной способности манипулятора за счет повышения эффективности автоматизированной системы управления технологическим процессом в процессе генерации и реализации оперативного управляющего влияния при режиме непосредственного автоматизированного управления.*

Методика. *В процессе исследований использован метод параметрического моделирования с привлечением положений дискретной математики. С помощью положений формальной логики было представлено описание схемы формирования параметров функциональной возможности манипулятора в переходном процессе при режиме непосредственного автоматизированного управления. С использованием положений теории графов был построен обобщенный связный граф. Решения этого графа с использованием превращения Розенберга-Карноппа и теоремы Келли-Ричардсона предоставило возможность получить корректируемую функцию оперативного управляющего влияния автоматизированной системы управления.*

Результаты. *На основании проведенных исследований выполнено параметрическое моделирование функциональной возможности манипулятора при непосредственном автоматизированном управлении. Сравнительный анализ результатов эксплуатации автоматизированной системы управления технологическим процессом со стандартной и корректируемой обобщенной функцией управляющего влияния в режиме непосредственного автома-*

тизированного управления показал, что при корректируемой функции управляющего влияния достигнуто уменьшение ошибки по точности позиционирования на 42,9%.

***Научная новизна**. Разработана параметрическая модель функциональной возможности манипулятора при непосредственном автоматизированном управлении. Особенность модели – возможность описания функциональной способности при переходном режиме функционирования манипулятора в процессе генерации и реализации оперативного управляющего влияния. Выполнено параметрическое моделирование функциональной способности манипулятора при непосредственном автоматизированном управлении.*

***Практическая значимость**. Полученные результаты направлены на обеспечение функциональной способности манипулятора в процессе генерации и реализации оперативного управляющего влияния при непосредственном автоматизированном управлении.*

***Ключевые слова:** манипулятор, параметрическая модель, функциональная способность, связный граф, переходный процесс.*

***Мета.** Мета статті полягає у забезпеченні функціональної спроможності маніпулятора за рахунок підвищення ефективності автоматизованої системи управління технологічним процесом у процесі генерації та реалізації оперативного управляючого впливу за режиму безпосереднього автоматизованого управління.*

***Методика.** У процесі досліджень використано метод параметричного моделювання з залученням положень дискретної математики. За допомогою положень формальної логіки було представлено опис схеми формування параметрів функціональної спроможності маніпулятора у перехідному процесі за режиму безпосереднього автоматизованого управління. З використанням положень теорії графів було побудовано узагальнений зв'язний граф. Розв'язання цього графу з використанням перетворення Розенберга-Карноппа та теореми Келлі-Річардсона надало змогу отримати кориговану функцію оперативного управляючого впливу автоматизованої системи управління.*

***Результати.** На підставі проведених досліджень виконано параметричне моделювання функціональної спроможності маніпулятора за безпосереднього автоматизованого управління. Порівняльний аналіз результатів експлуатації автоматизованої системи управління технологічним процесом із стандартною та коригованою узагальненою функцією управляючого впливу у режимі безпосереднього автоматизованого управління показав, що за коригованої функції управляючого впливу досягнуто зменшення помилки за точністю позиціонування на 42,9%.*

***Наукова новизна**. Розроблено параметричну модель функціональної спроможності маніпулятора за безпосереднього автоматизованого управління. Особливість моделі – можливість опису функціональної спроможності за перехідного режиму функціонування маніпулятора у процесі генерації та реалізації оперативного управляючого впливу. Виконано параметричне моделювання функціональної спроможності маніпулятора за безпосереднього автоматизованого управління.*

***Практична значущість**. Отримані результати спрямовано на забезпечення функціональної спроможності маніпулятора у процесі генерації та реалізації оперативного управляючого впливу за безпосереднього автоматизованого управління.*

***Ключові слова:** маніпулятор, параметрична модель, функціональна спроможність, зв'язний граф, перехідний процес.*

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