УДК 621.313:531.3

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POWER CONSUPTION SIMULATUIN BY THE MANIPULATOR IN A MODE OF IMMEDIATE AUTOMATED CONTROL

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МОДЕЛЮВАННЯ ЕНЕРЕГОСПОЖИВАННЯ МАНІПУЛЯТОРА ЗА РЕЖИМУ БЕЗПОСЕРЕДНЬОГО АВТОМАТИЗОВАНОГО УПРАВЛІННЯ

Objective. *The purpose of article lies in optimization of a power consumption of the manipulator in the course of realization of expeditious operation influence at a mode immediate automated control. It is reached at the expense of increase of effectiveness of an automated control system by technological process.*

Methods. *Being guided by provisions of the formal logic the description of a power consumption of the manipulator in transient phenomenon in a mode of immediate automated control was submitted. Research is conducted with use of the method of parametrical simulation on the basis of discrete mathematics. Using provisions of the graph theory the generalized coherent graph was contracted. The decision of this graph is given with use Rosenberg – Karnopp's transformation and Kelly-Richardson's theorem. The generalized corrective function of the description of a power consumption of the manipulator in a mode of immediate automated control in the course of realization of the quick managing director of influence of an automated control system is received by technological process.*

Results. *Simulation manipulator power consumption in a mode of immediate automated control in the course of realization of the quick managing director of influence is executed by an automated control system of technological process. The comparative analysis of results of operation of the manipulator with a reference and corrective generalized function of the description of a power consumption in a mode of immediate automated control in the course of realization of the quick managing director of influence by an automated control system for technological process showed that when using the corrected function decrease of the power consumption by 12,3% is reached.*

Scientific novelty*. The model of a power consumption of the manipulator in a mode of immediate automated control in the course of realization of the quick managing director of influence is developed by an automated control system for technological process. Feature of model makes that possibility of the description of a power consumption of the manipulator in a transient mode of function in the course of realization of the quick managing director of influence is presented. Simulation of a power consumption of the manipulator in a mode of immediate automated control in the course of realization of the quick managing director of influence is executed by an automated control system for technological process.*

Practical value. *The received results are directed on ensuring decrease of a power consumption of the manipulator in the course of realization of the quick managing director of influence at immediate automated control.*

Key words: *manipulator, model, power consumption, coherent graph, transient phenomenon, quick managing director.*

There are problem statements in a general view and with the major scientific or practical tasks. Instability of its dynamics and kinematics parameters has the considerable impact on power consumption the manipulator 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. Continuous realization start and stop take place. This event is accompanied as a rule by a reverse. As the result takes 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 power consumption 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 consider various aspects of use of the graph theory as in traditional treatment, and in aggregate with use of basic provisions of the theory of finite elements. 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] attempt of the description of power streams in lumped parameter system is made. However the description is given in a *generalized type of the integrated* power streams without a dynamic component. Authors [3], the same as authors [2], ignore the transient phenomenon at realization of the managing director of influence of an automated control system by technological process.

In [4; 5] features of application of the graph theory for technological process and equipment of discrete action are formulated. In [4] 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.

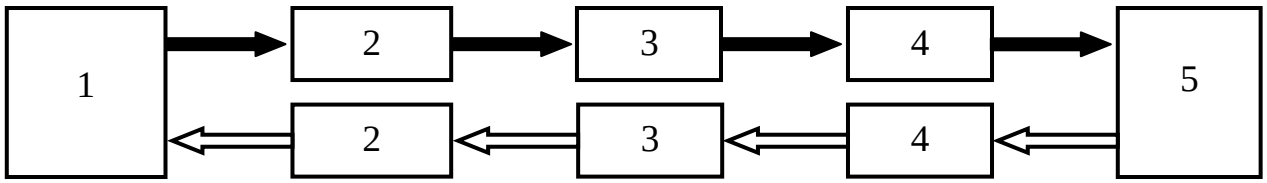
In [6; 7 and 8] results of application of the coherent graph for various aspects of research of transient phenomenon of oscillating character are given in branched loop system. In [6] results of simulation with use of a method of counts for multimass line system are given. In [7] analytical dependence 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 to provide productivity of an automated control system with technological process as simultaneous providing optimum power consumption at the realization of expeditious operating influence in a mode of immediate automated control. 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 the quick control director.

Statement of researches. In general view the manipulator represent system of discrete action dynamically linked by means of the moved is blown. It leads to a different orientation of power streams of the manipulator in a mode of immediate automated control in the course of realization of the quick managing director of influence is developed by an automated control system for technological process. The power streams of the manipulator in a mode of immediate automated control in a general view are formed as result (look figure 1).



1 – means, 2 – executive body; 3 – mechanical component; 4 – electric component; 5 – power source.

Figure 1 – The generalized scheme of power streams of the manipulator in a mode of immediate automated control

On figure 1 are provided:

⇨ – a power streams of the consumption;

➡ – a power streams of the generating.

According to figure 1 different orientation of power streams of the manipulator at dynamic circuit through a moved means can be compensated by power source of an electric component. It in principle gives the chance will reduce a power consumption the manipulator in a mode of immediate automated control in the course of realization of the quick managing director of influence by an automated control system for technological process. However thus used function of operating influence has to

consider surely power streams of transient phenomenon at realization of the quick managing director of influence is developed by an automated control system for technological process.

At dynamic coupling of executive bodies of the manipulator when moving means of realization operating influence of an automated control system by technological process in a mode immediate automated management the following scheme of power consumption take place (look figure 2).

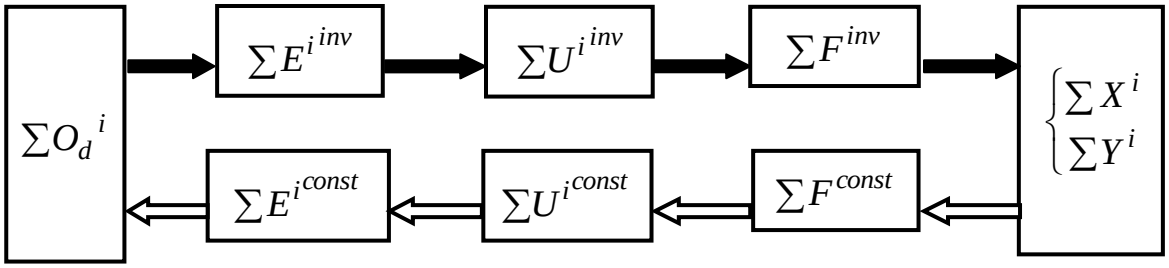


Figure 2 – The scheme of parameters formation of power consumption the manipulator in a mode of immediate automated control

According to figure 2 the following parameters formation of power consumption the manipulator in a mode of immediate automated control are defined:

$\sum Y^i$ – concrete parameters of power consumption the manipulator upon termination of realization of working stroke at a concrete stage by technological process;

$\sum X^i$ – concrete parameters of power consumption the manipulator before termination of realization of working stroke at a concrete stage by technological process;

$\sum F = \begin{cases} -\sum F^{inv}; \\ \sum F^{const}, \end{cases}$ – concrete parameters of power consumption the manipulator of the technological resistance of executive body at a concrete stage of realization operating influence of an automated control system by technological process in a mode immediate automated management;

$\sum U^i = \begin{cases} -\sum U^{i\,inv}; \\ \sum U^{i\,const}, \end{cases}$ – 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;

$\sum E^i = \begin{cases} -E^{i\,inv}; \\ E^{i\,const}, \end{cases}$ – concrete parameters of power consumption of the executive body manipulator at a concrete stage of realization operating influence of an automated control system by technological process in a mode immediate automated management;

$\sum \hat{I}_d^{\,i}$ – the unique terminating of positioning of power consumption 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);

const – constant power streams which take place at any stage of technological process;

inv – variable power streams which take place only as result of the transient phenomenon at realization of the managing director of influence of an automated control system by technological process;

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

Then streams of power consumption the manipulator a concrete stage of realization operating influence of an automated control system by technological process in a mode immediate automated management can be presented in the form of a parametrical dependence

$$\sum O_d{}^{i} = \begin{cases} \sum E^{i^{inv}} \Rightarrow \sum U^{i^{inv}} \Rightarrow \sum F^{inv} \Rightarrow \\ \sum E^{i^{\tilde{n}onst}} \Leftarrow \sum U^{i^{\tilde{n}onst}} \Leftarrow \sum F^{const} \Leftarrow \end{cases} \begin{cases} \sum X^{i} \\ \sum Y^{i} \end{cases}, \tag{1}$$

Parametrical dependence (1) can be formally present in the form of the abstract general model of system of transformations. The condition of such model is defined by a condition of an operand $\sum \hat{I}_d^i$. The operand $\sum \hat{I}_d^i$ fully expresses power consumption in a concrete stage of technological process in the form of a terminating set of transformation

$$\sum E^{i} = \begin{cases} -\sum E^{i^{inv}}; \\ \sum E^{i^{const}}, \end{cases} \tag{2}$$

According to (2) for the manipulator in a transient phenomenon of immediate automated management it is possible to construct generalized coherent graph of parameters formation of power consumption the manipulator in a mode of immediate automated control. This graph is presented in figure 3.

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).

$$E^{i}\left(e_{\underset{1}{i}}\right) = \begin{cases} E^{i}\left(e_{\underset{1}{i}}^{inv}\right) \dfrac{E^{1^{inv}}\left(e_{\underset{1}{1}}^{inv}\right) - E^{i^{inv}}\left(e_{\underset{1}{i}}^{inv}\right)}{E^{i^{inv}}\left(e_{\underset{1}{i}}^{inv}\right) - E^{1^{inv}}\left(e_{\underset{1}{1}}^{inv}\right)}; \\ E^{i}\left(e_{\underset{1}{i}}^{const}\right) \dfrac{E^{i^{const}}\left(e_{\underset{1}{i}}^{const}\right) - E^{i^{const}}\left(e_{\underset{1}{1}}^{const}\right)}{E^{1^{const}}\left(e_{\underset{1}{1}}^{const}\right) - E^{i^{const}}\left(e_{\underset{1}{i}}^{const}\right)}, \end{cases} \tag{3}$$

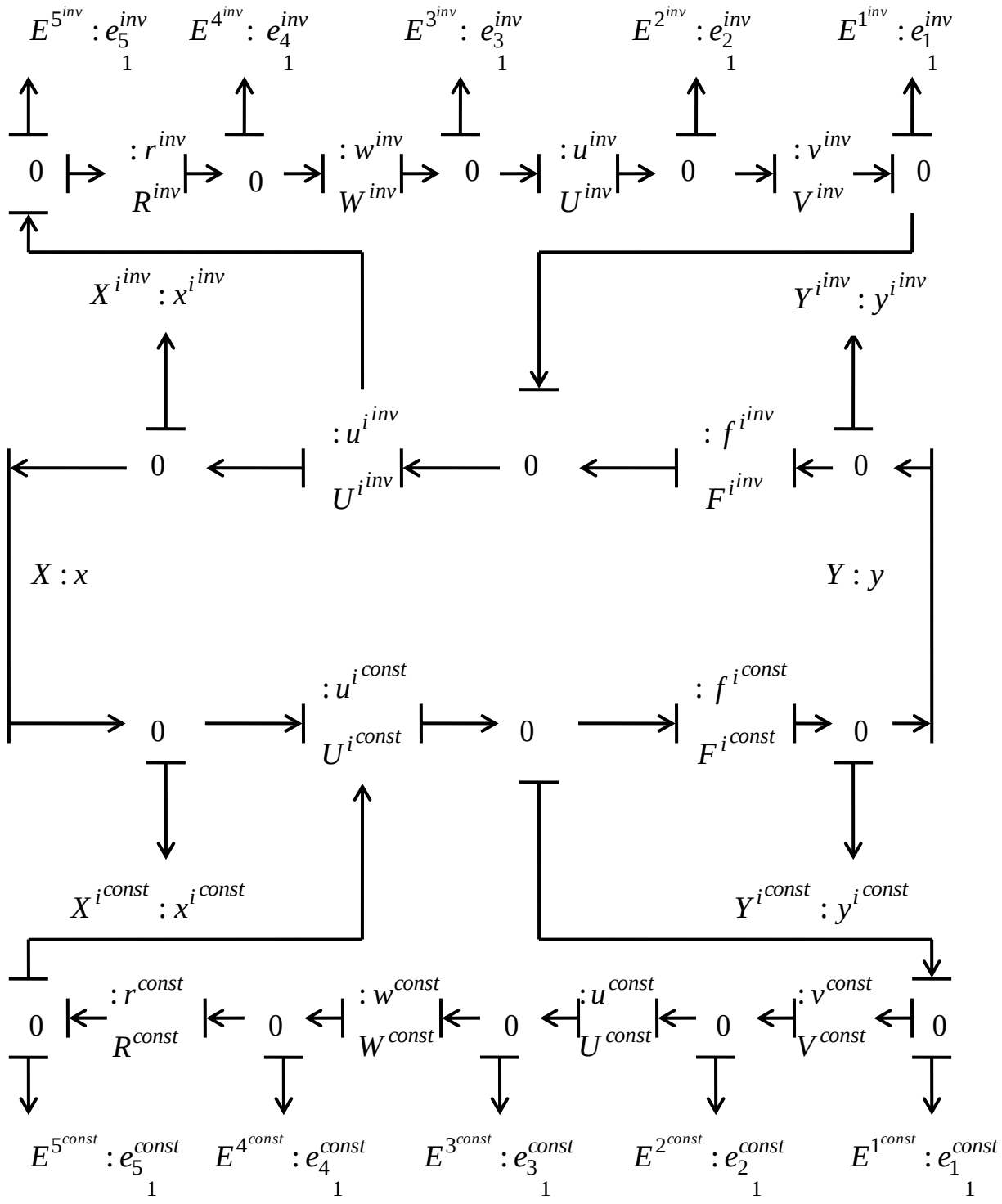


Figure 3 – The generalized coherent graph of parameters formation of power consumption the manipulator in a mode of immediate automated control

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 36,1% was reached at an

error of the kinematical parameters of 3,8% and time of attenuation dynamic oscillating process 19,2%. It is thus noted decrease in power consumption the manipulator in a mode of immediate automated control on 12,3%.

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 simultaneously in accuracy of positioning of executive body of the manipulator at achievement of optimum power consumption.

Practical significance. The received results are directed on ensuring the power consumption 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 at achievement of optimum power consumption 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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Мета. *Мета статті полягає в оптимізації енергоспоживання маніпулятора у процесі реалізації оперативного керуючого впливу за режиму безпосереднього автоматизованого управління за рахунок підвищення ефективності автоматизованої системи управління технологічним процесом.*

Методика. *Спираючись на положення формальної логіки, було наведено опис енергоспоживання маніпулятора в перехідному процесі за режиму безпосереднього автоматизованого управління.*

Дослідження здійснено з використанням методу параметричного моделювання на засадах дискретної математики.

Використовуючи положення теорії графів, було побудовано узагальнений зв'язний граф енергоспоживання маніпулятора. Розв'язання графа наведено з використанням перетворення Розенберга-Карноппа та теореми Келлі-Ричардсона.

Отримано узагальнену кориговану функцію опису енергоспоживання маніпулятора за режиму безпосереднього автоматизованого управління у процесі здійснення оперативного керуючого впливу автоматизованою системою управління технологічним процесом.

Результати. *Виконано моделювання енергоспоживання маніпулятора за режиму безпосереднього автоматизованого управління у процесі здійснення оперативного керуючого впливу автоматизованою системою управління технологічним процесом. Порівняльний аналіз результатів експлуатації маніпулятора зі стандартною та коригованою узагальненою функцією опису енергоспоживання маніпулятора за режиму безпосереднього автоматизованого управління у процесі здійснення оперативного керуючого впливу автоматизованою системою управління технологічним процесом показав, що за коригованої функції досягнуто зменшення енергоспоживання на 12,3%.*

Наукова новизна*. Розроблена модель енергоспоживання манипулятора за режиму безпосереднього автоматизованого управління у процесі здійснення оперативного керуючого впливу автоматизованою системою управління технологічним процесом. Особливість моделі – можливість опису енергоспоживання маніпулятора за перехідного режиму функціонування у процесі реалізації оперативного керуючого впливу. Виконано моделювання енерго-*

споживання маніпулятора за режиму безпосереднього автоматизованого управління у процесі здійснення оперативного керуючого впливу автоматизованою системою управління технологічним процесом.

***Практична значущість**. Отримані результати спрямовані на забезпечення зменшення енергоспоживання маніпулятора у процесі реалізації оперативного керуючого впливу за безпосереднього автоматизованого управління.*

***Ключові слова:** маніпулятор, модель, енергоспоживання, зв'язний граф, перехідний процес, оперативний керуючий вплив.*

***Цель.** Цель статьи состоит в оптимизации энергопотребления манипулятора в процессе реализации оперативного управляющего воздействия в режиме непосредственного автоматизированного управления путем повышения эффективности автоматизированной системы управления технологическим процессом.*

***Методика.** Опираясь на положения формальной логики, приведено описание энергопотребления манипулятора при переходном процессе в режиме непосредственного автоматизированного управления.*

Исследование осуществлено методом параметрического моделирования с использованием положений дискретной математики.

Используя положения теории графов, построен обобщенный связный граф энергопотребления манипулятора. Решение графа дано с использованием преобразования Розенберга-Карноппа и теоремы Келли-Ричардсона.

Получена обобщенная корректированная функция описания энергопотребления манипулятора в режиме непосредственного автоматизированного управления при осуществлении оперативного управляющего воздействия автоматизированной системой управления технологическим процессом.

***Результаты.** Выполнено моделирование энергопотребления манипулятора в режиме непосредственного автоматизированного управления при осуществлении оперативного управляющего воздействия автоматизированной системой управления технологическим процессом. Сравнительный анализ результатов эксплуатации манипулятора со стандартной и корректированной обобщенной функцией описания энергопотребления манипулятора в режиме непосредственного автоматизированного управления при осуществлении оперативного управляющего воздействия автоматизированной системой управления технологическим процессом показал, что при использовании корректированной функции достигнуто снижение энергопотребления на 12,3%.*

***Научная новизна**. Разработана модель энергопотребления манипулятора в режиме непосредственного автоматизированного управления при осуществлении оперативного управляющего воздействия автоматизированной системой управления технологическим процессом. Особенность модели – возможность описания энергопотребления манипулятора при переходном режиме функционирования в процессе реализации оперативного управляющего воздействия. Выполнено моделирование энергопотребления манипулятора при непосредственном автоматизированном управлении в процессе осуществления оперативного управляющего воздействия автоматизированной системой управления технологическим процессом.*

***Практическая значимость**. Полученные результаты позволяют обеспечить снижение энергопотребления манипулятора в процессе реализации оперативного управляющего воздействия при непосредственном автоматизированном управлении.*

***Ключевые слова:** манипулятор, модель, энергопотребление, связный граф, переходной процесс, оперативное управляющее воздействие.*

Рекомендовано до публікації д-ром техн. наук, проф. Матюхою П.Г.
Дата надходження рукопису 06.11.2013 р.