DESIGN FEATURES MECHATRONIC SYSTEMS MACHINES WITH PARALLEL KINEMATICS

Kovalevskyy S. V., Kovalevska O. S.

Рассмотрены основные преимущества и недостатки параллельных механизмов. Использование технологической машины позволяет рассматривать станок как контрольную измерительную машину и обрабатывающую. Впервые систематизированы подходы и средства для моделирования мехатронных систем, рассматриваются как разновидность систем автоматизированного управления. Рекомендовано в качестве инструмента моделирования мехатронной системы использовать ECAD системы, которые позволяют моделировать CAP и мехатронные системы в домене электроники благодаря наличию инструментов поведенческого моделирования. Предложен новый подход моделирования мехатронной системы в ECAD, теоретически и экспериментально определены его особенности, и область адекватности. Впервые, на основе определенных критериев выполнен сравнительный анализ программ CAE, CAS и ECAD, учитывая их применимость для моделирования мехатронной системы, на основе чего выработаны рекомендации по выбору программы и универсальная методика моделирования, имеет практическую ценность для инженеров-электронщиков, которые проектируют системы автоматического регулирования и управления механическими объектами.

Розглянуто основні переваги та недоліки паралельних механізмів. Використання технологічної машини дозволяє розглядати верстат як контрольну вимірювальну машину і обробну. Вперше систематизовано підходи та засоби для моделювання мехатронних систем, що розглядаються як різновид систем автоматизованого управління. Рекомендовано в якості інструмента моделювання мехатронної системи використовувати ECAD системи, які дозволяють моделювати CAP та мехатронні системи в домені електроніки завдяки наявності інструментів поведінкового моделювання. Запропоновано новий підхід моделювання мехатронної системи в ECAD, теоретично та експериментально визначені його особливості, та область адекватності. Вперше, на основі визначених критеріїв виконано порівняльний аналіз програм CAE, CAS та ECAD з огляду на їхню застосовність для моделювання мехатронної системи, на основі чого вироблені рекомендації по вибору програми та універсальна методика моделювання, що має практичну цінність для інженерів-електронників, які проектують системи автоматичного регулювання та управління механічними об’єктами.

The article considers the main advantages and disadvantages of parallel mechanisms. Using technology machines machine can be considered as a control and measuring machine manufacturing. First systematized approaches and tools for modeling mechatronic systems, considered as a kind of automated control systems. Tool mechatronic system simulation using ECAD system that can simulate the CAP and mechatronic systems in the domain of electronics thanks to the tools of behavioral modeling are recommended. A new approach mechatronic system simulation in ECAD, theoretically and experimentally by its features, and the adequacy of the region. For the first time, based on predefined criteria comparative analysis programs CAE, CAS and ECAD because of their applicability to simulation of mechatronic systems, based on what made recommendations on the choice of programs and universal method of simulation that has practical value for electronic engineers who design systems automatic control and management of mechanical objects.

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УДК 621.913

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Development and improvement of machine tools with parallel kinematics recent results in that feature new machines with is more universal. Technological machine can be considered as a control and measuring machine manufacturing. The actual number of levels exceeding six known and allows the presence of a large number of measuring heads manipulation and control. With the instrumental node management program consolidation and unfastening can serve industrial robot programming. With such equipment capabilities provide flexibility could be considered flexible industrial sites not only as technological but also as a structuring flexibility. Universal CNC in the area, CNC systems and flexible manufacturing systems they have to move into a new stage where the organization machinist's workplace is not about money machine by increasing the level of automation or by increasing workplace automation support operations of technological provisions, systems, storage, delivery, chips-cleaning general increase in automation and equipment necessary workplace machines with mobile organizations working environment through mobile storage – shops and efficiently scheduling production on an "in trouble."

The urgency is confirmed by numerous sources appeals to researchers in the field of new high-performance technology. Thus, the quality of information gets more weight if this information contains critical analysis (Tab. 1)

Table 1

Advantages and disadvantages of parallel mechanisms

Advantages parallel	Disadvantages of parallel mechanisms
The machinery	Rigidity relatively small workspace
The ability to manipulate large loads Opportunity interference supports	Increased precision displacement availability of special provisions where there is a loss of control
The simplicity of the mechanism elements and their assembly	The possibility of a simple scaling circuit device dependent nonlinear kinematics and dynamics from the point of workspace
Lightweight, low metal structures at comparable stiffness	Difficulty best dynamic performance management system
Advantages parallel	Disadvantages of parallel mechanisms
The machinery	Rigidity relatively small workspace
The ability to manipulate large loads Opportunity interference supports	Increased precision displacement availability of special provisions where there is a loss of control

Structured information in accordance with the general requirements of its submission and the specific samples in the field of mobile intelligent machine technology becomes a source of further development of design, technology and research.

Information support of mechatronic systems.

Electronic devices are often used in mechatronic systems that are able to provide the executive body motion control action under electronic control system. Mechatronic system is a synergistic combination of mechanical subsystems and subsystems power electronics and information, therefore, when designing mechatronic system must use systems engineering principles, while detailed analysis of physical phenomena in each of the subsystems. I t is clear that such an analysis requires engineers with bringing the relevant industries, but the top level of abstraction, mechatron-

ic system can provide automatic control system, or control, which may engage in designing engineers of electronic equipment. Specific view mechatronic system, as the objects of research and modeling specialist for electronics is presented in this article.

Modeling of mechatronic systems requires software that can provide research on different hierarchical levels – a program-aided design (CAD), engineering (CAE) and universal mathematical processors (CAS) [1, 2].

Mechatronic systems are a purely theoretical or materials, or apply only to engineers and mechanics system technical [3]. Currently, researchers from the field of e no objective advice on choosing the most suitable software for mechatronic system simulation their development is an urgent task. Therefore the aim of this work is to develop methods and mathematical software aided design mechatronic systems such as production techniques and practical advice for selecting the best software and mathematical software, including study the possibility of using ECAD, computer-aided design in electronics for modeling of mechatronic systems based on the new approach in modeling.

The object of the study is the simulation of mechatronic systems and automated control systems, the subject of investigation – software of CAE, CAD and CAS-systems suitable for modeling and simulation of mechatronic systems.

Machine tools with parallel kinematics, as a form of dynamic system [3] intended for the implementation of a given movement and are a foundation of the actuator and drive – electromechanical, hydraulic or some other. Examples of modern mechatronic devices are units of machine tools and industrial robots, household appliances and more.

Usually mechatronic system modeled on the upper level of abstraction (macro level), which distinguish structural (block) and physical Multi approaches, each with its own advantages and disadvantages [4, 5], thus for each of the two methods can be certain core features of mathematical chosen software. Madelyn accuracy depends on the number of recorded parameters of the system, the accuracy of simulation – the right of the selected user account features tools and software used. Despite continuous development as mechatronic systems and means of research, analysis and software modeling approaches [6] is an urgent task, a decision which will enhance the quality of decisions in the design of mechatronic systems. Any mechatronic systems requires management (ACS), and must be identified for the construction of the model to create the required control device that provides a complex coordinated movement of mechanical parts [3, 4]. The behavior patterns of a mechatronic system can, in some approximation, judge the behavior of the real system, because of the difficulty or impossibility of testing on a real system makes sense [2]. As mechatronic systems include electromechanical transducers with electronic commutation (actuators), sensors, power semiconductor converters, microcontrollers and personal computers, it guarantees a wide range of research to specialist electronic equipment.

The modeling of mechatronic systems includes the following steps:

– Organization and research models and digital power electronics, continuous models (mechanical) parts;

– study the characteristics of the system as a whole (as ATS / ACS).

Therefore, you must use a domain simulation (the first stage) and causal (the second stage). Conducted literature review showed that the recommended MCAD [5], CAE [7] CAS [7], graph theory (system level of abstraction at which the system is not broken down into building blocks, subsystems) and Markov chains [1]. The authors are different ways of classifying programs, for example – division of the application of static and dynamic modeling [2].

Most of the works have a theoretical value, description of software (CAS and CAE) [3, 4] is intended mainly for specialists in systems engineering. The ability to use ECAD (Electronics Computer Aided Design) for modeling of mechatronic systems is not considered. However, according to experts of the electronics needed clear guidance on the selection of available software, which when adopted mechatronic systems approach modeled adequately. With CAD-systems for the design

of mechatronic systems using MCAD (Mechanical Computer Aided Design) [5], which are designed for multi-dimensional solid modeling of mechanical systems. Thus the basis modeling is the study of mechanical structures.

CAE systems allow you to explore the system at the macro level, that is, analyze and optimize system with the aim of deciding on the topology (structural approach) and the functionality of the whole (system approach).

Some CAE, including a 20-sim, there are libraries that include different models of electromechanical devices (Mechatronic Toolbox) [1, 2]. Most of these models cover the all aspects of specific mechatronic devices and from this point of view are very useful to designers that develop mechatronic systems. Editor and designer filter regulators are also important in the creation of ACS and their analysis.

Although the programs examined (except CAS) is an object-oriented, they share certain principles Madelyn and simulation, which can be summarized as approach. As mechatronic systems as an option dynamic system is complex system [8], it can be modeled using Multi approach, but at the same time, the mechatronic system constructed as ACS, traditionally analyzed in the causal approach so effectively study mechatronic system the challenge is choosing the optimal approach and this software supports it. Consider these approaches in terms of specialist electronics for the formation of criteria to select the most suitable software for research on higher levels of abstraction, systemic and structural.

As noted above, mechatronic systems – is the hierarchical structure of the elements combined in subsystems of different levels, which can be of different physical nature (with different domains). Since the structural level simulation model structure follows the structure of the object, the mechatronic system model is a composition of blocks that interact through functional links. Since the energy chain energy flow can change direction, and then the elements of physical circuit's inputs and outputs defined. This approach should choose programs (Multi) modeling [7, 1].

An analysis of the applications, modeling technique is based on the model element library devices with different power domains (electrical, mechanical, hydraulic, and so on. D.) From which you can draw the equivalent circuit as a physical concept that describes the system algebra- differential equations.

The essence of the approach is different in that during modeling can go to a set of differential equations (after the procedure), and then all the physical characteristics of individual parts of the system will be lost. A variant of this approach is causal modeling, where blocks can be seen as transducers input signals at the weekend, while retaining the causal link. Causal model used in the system (highest) level of abstraction for assessing system performance. Since the building blocks with inputs and outputs, built under this model technique is sometimes called the directional signal graphs. A special case of this modeling technique is the use of graphs relations BG (bond graph) [1].

Create the criteria for selecting the optimal software by analyzing the characteristics and quality of modeling in the above approaches to modeling allowing for the mathematical model of software programs of different classes (CAE, ECAD, and CAS).

The study models, simulation tools and postprocessors [2] different programs showed that causal modeling often associated explicit solver (solver) for simulation, which is a library of classic numerical integration routines that implement explicit integration methods. As you know, explicit methods may lose stability for hard mathematical models (which are peculiar to mechatronic systems), moreover, possible reasons for failure algorithmic topological degenerate [7, 2]. Thus, we can conclude that the simulation results are inadequate for systems with large time constants spread and in the presence of structural singularities - modeling in general is impossible. Some modern CAE be able to solve these problems automatically, which is confirmed by the analysis of algebraic structures with loops among the 20-sim [8].

With physical modeling Multi usually associated iterative solver that implements implicit methods of integration, in which every step of integration initially formed nonlinear system of algebraic equations is solved on iterative method (Newton). The features implicit methods are that we should not artificially break system to organize the flow calculations; moreover, they have a large area of stability [2], which provides reliable simulation.

ECAD intended primarily for the design of electronic domain (at the schematic level), but when they became rich possibilities of behavioral (behavioral) simulation first for digital circuits, and also for analog, it is possible to raise the level of abstraction for functional and even system level [1], and expand the class of objects for modeling. Unlike behavioral models of digital devices (written for deterministic algorithm simulation of the event), behaviors of continuous objects based on implicit numerical integration algorithm that underlies the simulation at approach and provide the possibility of building a fairly complex algorithms to emulate the functioning. Thus, the use of ECAD to study mechatronic systems and ACS is one of the factors for ensuring the adequacy of the results.

In ECAD model can also make the mechatronic system based on standard units ACS. Signal in blocks and elements ACS achieved galvanic isolation of inputs and outputs through the current source and voltage-managed stress, so the nature of the causal model can be built in essentially program that can be called approach to modeling. Relations between functional converters in mechatronic sytstemi, presented as ACS, are shown in (Fig. 1): thin arrows model the information flow, thick – energy.

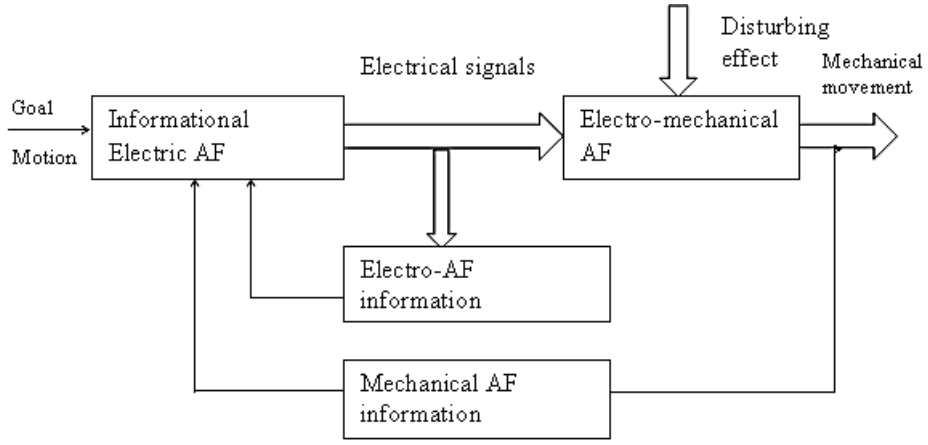

Fig. 1. Information and energy flows in ACS mechatronic system

During the process of functioning of human-machine systems means a series of actions and operations system elements, combined into a single sequence targeted through the management and provides of elements that forms from disparate range of individual functions to a coherent logical and temporal sequence, stable to disturbances and leads to the achievement of the goal (or goals) operation. In general, the process proceeds to the goal of interrelated elements HMS spaces E, of the functions F, states HMS S, W of developments and indicators HMS Q (Fig. 2).

The models used to study the functioning of discrete HMS can be divided into the following main classes [8]:

– Formal algebraic system (Mark and semi-Markov processes, regression models, algebraic models of queuing theory);

– Linguistic formal systems (formal grammars, Petri nets, logic circuits and automatic algorithms Lyapunov logical and linguistic model of situational management, Yanov schemes);

– Language and algebra (precedence network, network GERT, PERT, critical path method network, the combination of E-networks evaluative method methods piecewise linear automata, functional and functional-semantic networks, algorithmic and probabilistic and fuzzy-algorithmic model).

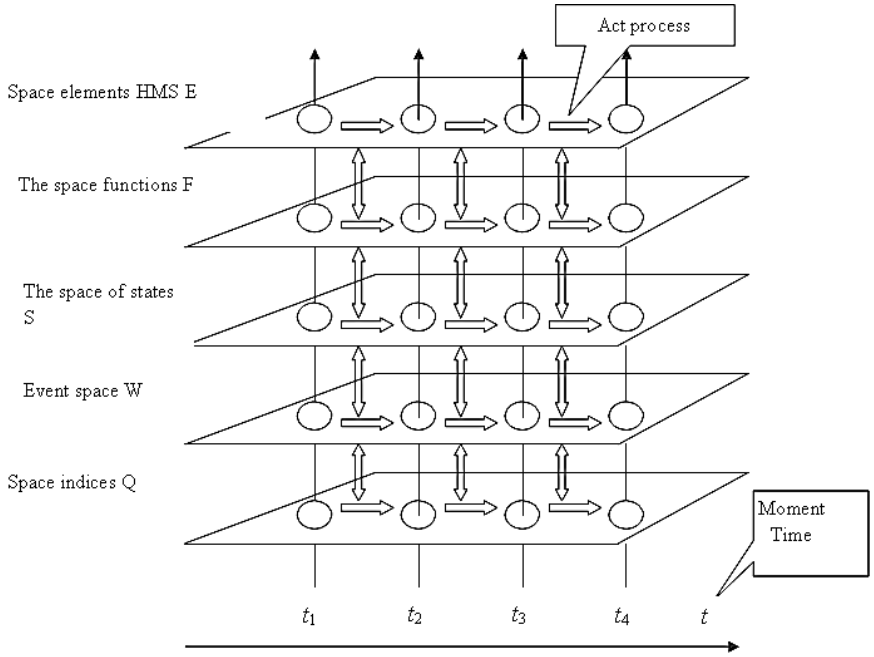

Fig. 2. Space description of the functioning of HMS

CONCLUSIONS

The paper first systematized approaches and tools for modeling mechatronic systems, considered as a form of ACS, focused on the researcher, who is a specialist in the field of electronics. Tool mechatronic system simulation using ECAD system that can simulate the CAP and mechatronic systems in the domain of electronics thanks to the tools of behavioral modeling are recommended. A well kvazikauzalnyy approach mechatronic system simulation in ECAD, theoretically and experimentally by its features, and the adequacy of the region.

For the first time, based on predefined criteria comparative analysis programs CAE, CAS and ECAD because of their applicability to simulation of mechatronic systems, based on what made recommendations on the choice of programs and universal method of simulation that has practical value for electronic engineers who design systems automatic control and management of mechanical objects.

Prospects for future research are to broaden the criteria as modeling and simulation area of optimization and methodological support ACS-aided design / mechatronic system.

REFERENCES

1. Vasilenko V. N. Labor Organization machinists: Theory and practice of increase of efficiency: Monograph / V. N. Vasilenko, V. S. Zaitsev; scientific. Ed. V. N. Vasilenko; National Academy of Sciences of Ukraine, Institute of Economic and Legal Research. – Donetsk : South-East, 2014. – 260 p.

2. Petrenko Y. I. Research of algorithms and development of modeling and simulation technique of automatic control systems in 20-sim / Y. I. Petrenko // Materials XVII scientific conference of students, undergraduates, graduate students and faculty of Zaporizhzhya State Engineering Academy. – Zaporizhzhia : ZDIA 2013. – S. 48–49.

3. On the program for the simulation of automatic control systems SamSim [Electron resource]. – Access mode: http://samsim2002.chat.ru

4. B. Modeling systems. Dynamic and hybrid systems: Textbook / Y. B. Kolesov, Yu. B. Senichenkov. – SPb. : BHV-Petersburg, 2006. – 224 p.

5. [Электронный ресурс]. – Режим доступа: http://tekhnosfera.com/kinematicheskiy-i-silovoy-analiz-ploski.

6. LMS IMAGINE.LAB AMESIM [Электронный ресурс]. – Режим доступа: http://novatest.ru/equipment/raschetno-eksperimentalnoe_modelirovanie/mehatronika,_modelirovanie/lms_imagine.lab_amesim

7. [Электронный ресурс]. – Режим доступа: http://www.internet-technologies.ru/how-to-create-internet magazine.html.

8. Borisenko A. A. Web-design. Just as ABC. – M. : Eksmo, 2008. – 320 p.

Received 10.10.2017.