Development of Scientific and Educational System: European Vector – 2023

Series of monographs
Slovak Publishing House
NES Nová Dubnica s.r.o.
Monograph 1

Publishing House NES Nová Dubnica s.r.o., 2023

Series of monographs Slovak Publishing House NES Nová Dubnica s.r.o., Slovenská Republika

Monograph 1

ISBN 988 – 963 – 8454 – 15 – 6 - 6S

Editorial compilation
Publishing House NES Nová Dubnica s.r.o.
M.Gorkého 820/27, P.O.BOX
018 51 Nová Dubnica, Slovenská Republika
tel. +421-42-4401 209

TABLE OF CONTENTS

CHAPTER 3. ELECTROMECHATRONIC COMPLEXES AND MODULES

3.1. Modular Systems of Electromechatronic Complexes

Modular systems of electromechatronic complexes consist of a mechanical part, a drive (mainly electromechanical) part, as well as a control system [3, 4–8].

Elements of the mechanical part:

– a working body (a winch of a crane, an impeller of a pump, a cutter of a metal-cutting machine), which performs useful mechanical work (moving cargo, machining a part, etc.);

– a mechanical transmission that transmits the speed of movement or its nature (progressive instead of rotary) to another system.

The task of the drive part (electric drive) is to convert electrical energy into mechanical energy and drive the working bodies of electromechanical elements.

The electromechanical drive part consists of an electric motor and an electronic power converter that converts the electrical energy consumed from the source (power supply system) into a form suitable for powering the motor windings. It is through this converter that the speed, effort and position of the engine shaft and, ultimately, the working body are controlled.

Recently, in the construction of electromechanical complexes of the new generation, there is a tendency to transfer an increasing number of functions from mechanical units to intellectual ones (electronic, computer, information). The control system of the mechatronic complex consists of intelligent functions.

The complex's intelligent nodes can be easily reprogrammed for a new task, which expands its functionality. Together with the development of technology, the nodes of the elements of the complex have different physical origins (mechanical, electrical, electromechanical, electronic, informational). But this does not prevent them from gradually merging into a single constructive circle.

At the heart of the key element of mechatronic systems is a movement module, for example, which combines a drive electric motor and an industrial gearbox in one complex (Fig. 3.1.1). This increases the reliability of electric machines and simplifies their development.

The miniaturization of power and control electronics made it possible to constructively combine electronic components with electromechanical components. Intelligent mechatronic modules (hereinafter referred to as IMMD) appeared in the form of engines and motor-reducers with power converters (frequency converters) on board (Fig. 3.1.2).

Figure 3.1.1 – Gearmotors:
1 – electric motor; 2 – reducer; 3 – output shaft of the gearbox

Figure 3.1.2 – Motors and motor-reducers with built-in
frequency converters (1)

Due to the presence of computing devices in their composition, such devices are capable of autonomously moving the working bodies of machines without constant control from the upper-level automation system.

A significant simplification of the mechanical part can be achieved by using linear motors instead of conventional rotary motion motors (Fig. 3.1.3).

Figure 3.1.3 – Linear motor and basic elements

A linear motor has no rotating parts. Its moving part has a winding that creates a magnetic field. This magnetic field repels the stationary part with permanent magnets, which plays the role of guides, and provides translational movement of the moving part of the engine.

To implement precise movements, mechatronic modules are also equipped with a position sensor (encoder, Fig. 3.1.4, a). An electric drive equipped with such a sensor is called a servo drive. Motion control systems that combine several servo drives include motion control controllers (servo controllers, Fig. 3.1.4, b).

Figure 3.1.4 – Appearance of encoders (a) and servo controllers (b)

The main advantages of using intelligent mechatronic modules in electromechanical complexes:

– the ability to perform complex movements independently, without referring to the controller of the upper management level, which increases the autonomy of modules, flexibility and survivability of mechatronic systems;

– simplification of communication between modules and the central control device;

– increasing the reliability and safety of mechatronic systems thanks to computer diagnostics of damage to automatic protection in emergency situations;

– creation of distributed automation systems on the basis of IMM, which are characterized by the delegation of management functions "from above"/"below", as well as the wide use of network technologies for information exchange;

– the use of intelligent sensors in the IMM leads to an increase in the accuracy of measurements due to the primary processing of information, noise filtering, etc.

The main functions of servo controllers include the coordination of movements of individual servo drives (mechatronic modules) and the formation of movement tasks for them in order to implement complex spatial trajectories of movement.

3.2. Modern Control in Electromechatronic Modules and Complexes

Modern management of systems and complexes is based on the work of microprocessors and microcontrollers, which are widely used in energy, transport, industrial production and other industries.

Any computer is a machine for processing information, regardless of what specific task it performs. The central element of a computer is a microprocessor.

A microprocessor is a microelectronic programmable device designed to process information and control the processes of exchanging this information as part of a microprocessor system (computer).

Microprocessors are created using modern microelectronics technologies based on a semiconductor crystal. Information is transmitted to microprocessor systems thanks to electrical impulses.

Structurally, the microprocessor is made in the form of microcircuits that have a plastic or ceramic case. A miniature semiconductor substrate is placed inside the case (Fig. 3.2.1).

All electronic circuits of the microprocessor are "drawn" on this substrate with a laser. The inputs and outputs of the circuit on the substrate are connected to metal terminals located on the sides or bottom of the chip body.

Microprocessor systems are generally universal. They are able to perform a wide range of information processing tasks. And the microprocessor is "configured" to perform a specific task using a program (a sequential list of machine commands).

а б

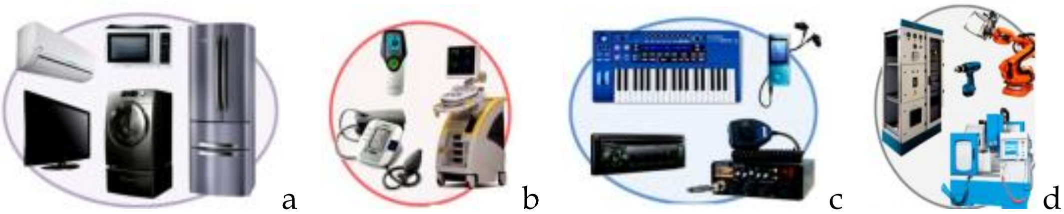
Figure 3.2.1 – Integrated microcircuit (a) and its internal structure (b)

Mandatory components of a microprocessor are registers, an arithmetic logic device and a control unit.

A microprocessor cannot work by itself. It is the central link of the microprocessor system, which also includes permanent and operational memory devices, information input and output devices, drives on hard magnetic disks (so-called "hard drives"), etc.

A microcontroller is a specialized microelectronic programmable device. It is designed to control data transmission systems and technological processes.

Microcontrollers are used in various complexes and systems, as well as in transport, power supply and power supply systems (Fig. 3.2.2).




e


f

Figure 3.2.2 – Fields of application of microcontrollers:
a – household appliances; b – medical equipment; c – means of communication and electronic equipment; d – works and equipment; e – vehicles;
f – power supply and power supply systems

A microcontroller, unlike a microprocessor, usually has a small bit size (8–16 bits) and a rich set of instructions for manipulating individual bits. Another of the main differences between a microcontroller and a microprocessor is that the controller microcircuit contains all the necessary elements for building a control system. Inside the microcontroller are data memory (random access memory), program memory (volatile memory), clock generator, timers, counters, parallel and serial ports. Thanks to this, a system of minimal configuration based on a microcontroller can consist of a power supply unit, a direct microcircuit of the controller and several passive elements (resistors, capacitors and a quartz resonator).

A typical microcontroller architecture (Fig. 3.2.3) includes a synchronization and control system (1), an arithmetic logic device (2), general-purpose registers (3), data memory (4) and program memory (5), ports (6), functional devices (timers, counters, pulse width modulators, interfaces) and registers for their configuration (7).

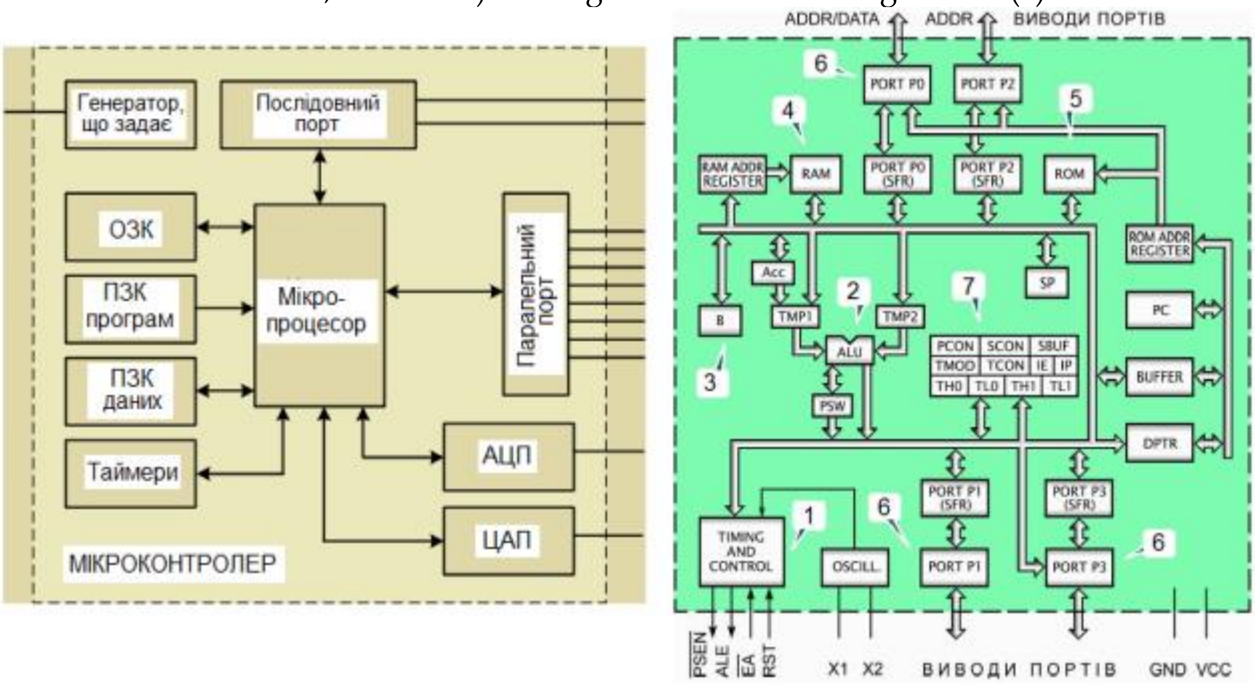


Figure 3.2.3 – Architecture of a modern typical microcontroller

Programs for microcontrollers are created in special integrated tool environments (Integrated Development Environment, IDE) in assembler (machine commands) or C++ languages.

Every year, billions of programmable microcontrollers and microprocessors are sold in the world, which have a large modification and are an integral part of the modern technological environment (Fig. 3.2.4).

Hardware and software unification of microcontrollers and microprocessors makes it possible to easily switch to systems of another manufacturer, to transfer programs from one platform to another. This increases the flexibility of automation processes, promotes competitive innovative development of world experience.

In addition to general-purpose microprocessors and microcontrollers, so-called signal processors specially designed for real-time signal processing are available on the market. They are used in power supply systems, measuring devices, means of communication, transmission and reproduction of audio and video streams, location systems and others.

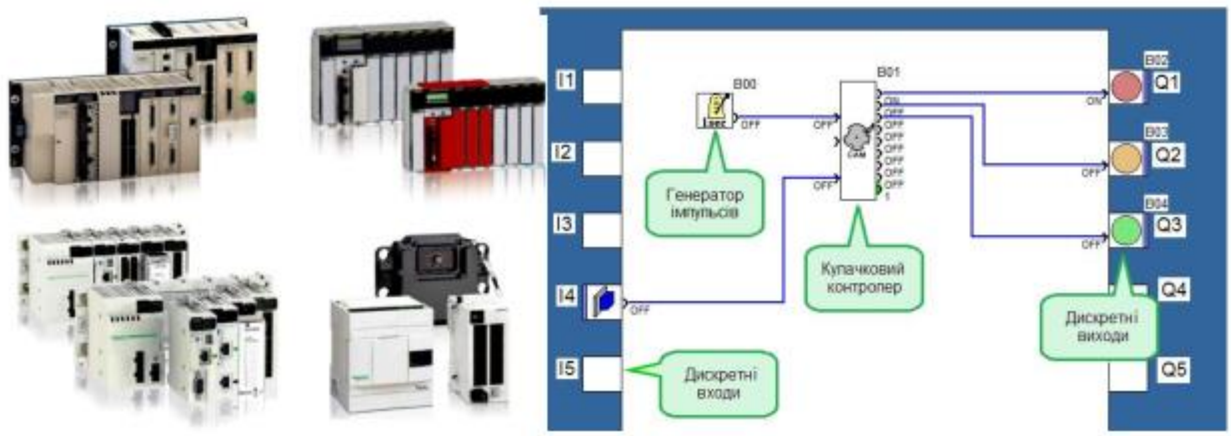


Figure 3.2.4 – Programmable logic microcontrollers and programs

3.3. Robotic Electromechatronic Systems and Modules

The modern trend in the design and production of equipment is the use of the block-module principle. For mechatronic systems, such modules are mechatronic motion modules - a synergistic combination of mechanical (hydromechanical, pneumomechanical), electrotechnical, electronic components and information and software tools that realize the achievement of a given controlled movement. This makes it possible to decompose complex systems, reducing the number of degrees of freedom, and obtain their necessary hierarchical structure.

In many areas of technology, mechatronic systems replace traditional electrical and mechanical machines that no longer meet modern quality requirements. The mechatronic approach in the construction of new-generation machines consists in transferring the functional load from mechanical units to intelligent, electronic, computer-informational components, which are easily reprogrammed for a new task and at the same time have a low cost. For example, the functional analysis of new production machines proves that the share of the mechanical part has today decreased from 70% (in the early 90s) to 25–30%. It is fundamentally important to emphasize that the mechatronic approach in design involves not expanding, but rather replacing the functions traditionally performed by the mechanical elements of the system with electronic and computer units.

Modern technological and mobile machines (NPC machines, automatic lines, industrial robots, etc.) contain several mechatronic movement modules that carry out movement in space of working bodies and executive mechanisms according to a predetermined program trajectory.

The characteristics of the technological environment are determined with the help of analytical and experimental studies and computer modeling methods. If such research requires complex and expensive devices and measuring technologies, then it is advisable to use adaptive control methods that make it possible to automatically adjust the laws of movement of working bodies directly during the operation using external sensors of the machine's information system.

Currently, technological machines – hexapods (Fig. 3.3.1), which are used in the energy and transport industries, are widely used for diagnostics and maintenance of power lines and contact lines urban electric transport networks and protection systems.

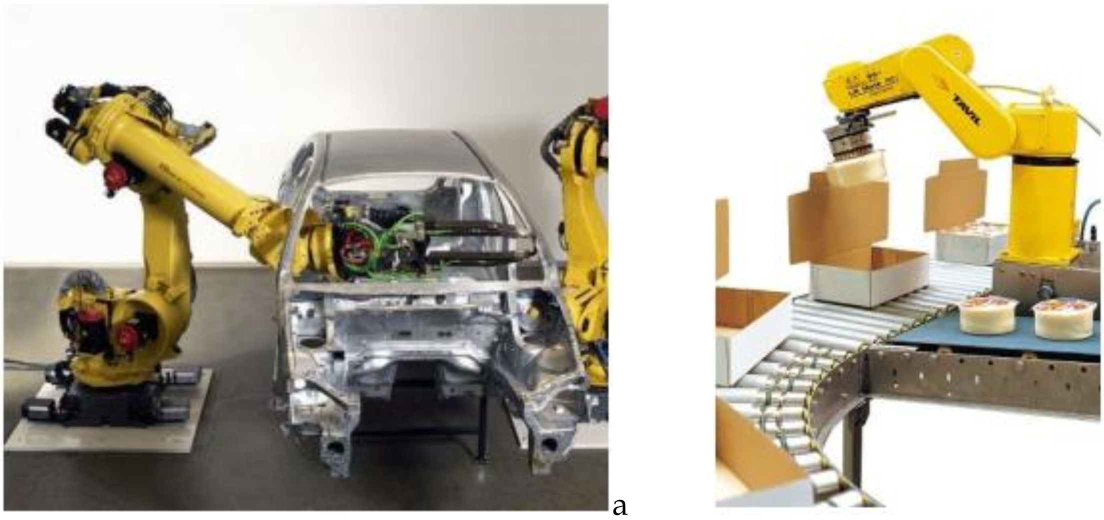
Figure 3.3.1 – General view of hexapod technological machines

Such hexapods can also be machine tools, coordinate measuring machines. At the heart of their design scheme is the Hugh-Stewart platform. A feature of such machines is the mechanism, which has six independent legs on hinged joints. The length of the legs can be changed, which leads to a change in the orientation of the platform.

The synthesis of new precision, information and measurement science-intensive technologies provides a basis for the design and manufacture of intelligent mechatronic modules and systems. In the future, mechatronic machines and systems will be combined into mechatronic complexes based on unified integration platforms.

The purpose of creating such complexes is to achieve a combination of high productivity and at the same time flexibility of the technical and technological environment due to the possibility of its reconfiguration. This will make it possible to ensure the competitiveness and high quality of mechatronics products produced in the markets of the XXI century.

Robots and manipulators are a vivid example of a mechatronic system (Fig. 3.3.2). They are increasingly used for welding and painting, assembly operations, electronic printed circuit board manufacturing, metalworking, in space research and even in everyday life.



a b

Figure 3.3.2 – Industrial works: a – welding; b – packing

Some types of robots are similar in design and purpose to a human hand. Other robotic systems create automatic movement of loads, so they look like carts (Fig. 3.3.3).

Figure 3.3.3 – Robocar (automatic cart)

A typical mechatronic system is a machine tool with numerical program control (hereinafter referred to as NPC), which is used for mechanical processing of metal, wood, and plastic products (Fig. 3.3.4). The operation of the movement modules is coordinated by the digital NPC system, which is preloaded with the processing program.

Mechatronic modules and systems are also used:

– in the automotive industry (for example, anti-lock brake systems, vehicle motion stabilization and automatic parking systems, autopilots);

– 3D-printers (Fig. 3.3.5);

– non-traditional means of transport (electric bicycles, segways, wheelchairs, drones, Fig. 3.3.6);

– office equipment (for example, copiers and fax machines);

– elements of computing equipment (printers, plotters, disk drives);

– technological lines and packaging machines of the food and processing industry;

– printing machines;

– household appliances (washing machines, sewing machines, dishwashers and other machines) and photo and video equipment;

– medical equipment (rehabilitation, clinical, service);

– simulators for training pilots and operators, etc.

a

b

Figure 3.3.4 – CNC machine tools: a – lathe; b – milling

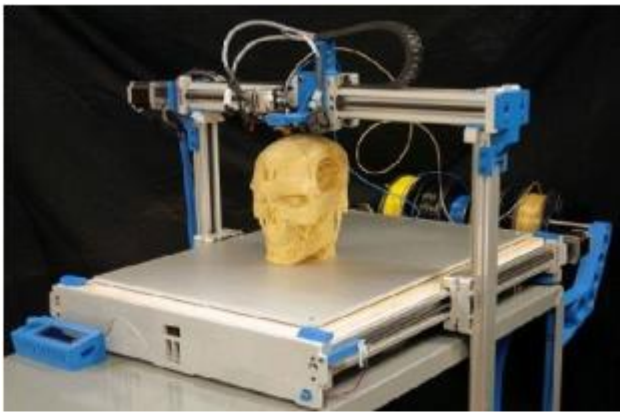


Figure 3.3.5 – 3D-printer

Figure 3.3.6 – Drone

Today, intelligent systems are widely used in other countries and in Ukraine. These control systems can be used for any type of transport: railway, urban electric, road, air and water.

An example of another innovative solution is the use of electromechatronic systems in nuclear energy.

Such complexes or systems include work in radiation exploration. As the experience of conducting radiation surveys proves, there are many sources of radiation that may not be recorded by radiometric systems in space. Therefore, the use of standard radiometers is ineffective. In this regard, robotic systems (Fig. 3.3.7) with collimated radiometry technologies can be used for measurements.

Figure 6.15 – Robotic mechatronic systems for nuclear energy

Such robots are equipped with open and collimated detectors, video cameras, etc. Open detectors measure the power of the radiation dose at the point of placement of the measuring unit. The collimated detector measures radiation fluxes. Video cameras usually have an optical zoom, which allows you to examine the subject in detail.

Robotic systems can function in very difficult conditions: at high and low temperatures, collapses, gassing, dustiness, radiation and electromagnetic fields, etc.

Robots can perform the functions of equipment carriers for the examination of radiation-hazardous objects. Therefore, robotics makes it possible to carry out the most effective radiation reconnaissance, bypassing the presence of a person at the object.

Robots are widely used to eliminate the consequences of accidents by collecting radiation samples, cleaning buildings from debris and deactivating nuclear reactors. The impetus for the development of the global market of robotics for the purpose of eliminating the consequences of accidents at nuclear power plants was provided by the disaster that occurred at Fukushima-1. In this case, remotely controlled robotic systems were used to decommission a nuclear reactor in order to reduce high levels of radiation.

Today, the global market continues to develop in the direction of creating intelligent mechatronic systems.

3.4. Modeling of the Dynamics of Mechatronic Complexes and Modules

Methods of mathematical modeling and design of mechatronic systems being developed should be based on a single, comprehensive approach to the design object [4].

A model (from the Latin Modulus – sample, measure) is a device that possesses the main properties of the object under study.

Modeling as a research method is used when the research object is partially or completely unavailable for any reason. Such a situation arises in the case of designing a fundamentally new technique, since in order to substantiate the adopted design decisions, it is necessary to study a system that does not yet exist physically.

Modeling can be:

– natural, when the model has the same physical origin as the object under study;

– analog, when the model and the object have different physical origins.

If the properties of the object under study are expressed by mathematical relations (equations, inequalities), then it is said that there is a mathematical model.

The high level of development of computer technology and software, achieved up to now, allows to consider mathematical modeling as a powerful tool of scientific research. Due to the fact that mechatronic systems are technically complex products, their design and preparation for production, as well as the importance of mathematical modeling using computers, is decisive.

Therefore, the system of automatic design (hereinafter referred to as SAD) of mechatronic systems necessarily includes a subsystem of mathematical modeling of dynamics, which allows to develop dynamic models of the designed product in an automated mode, conduct research, and solve engineering problems of optimization and synthesis.

The tasks of automation of modeling, research and design of mechatronic complexes and systems use the following forms of presentation of mathematical models of dynamics:

– a system of differential equations;

– connected graphs;

– structural and dynamic scheme.

The dynamics equation is the most general form of presentation of a mathematical model of a mechatronic system or its individual subsystems. They are equations that relate the coordinates of the system, its velocities and accelerations to the forces acting on the system. Coordinates can be not only the linear and angular positions of the links of the mechanical part of the machine, but also the volumes of the working fluid of the hydraulic drive, electric charges flowing through the cross-sections of the conductors, etc.

Power parameters in the equations of the dynamics of a mechatronic system, in addition to "mechanical" forces and their moments relative to any axes, can also be the pressure of the working fluid (gas), electric voltage, etc.

The formation of the dynamics equations of the electromechanical system in generalized coordinates can be carried out by the Lagrange method, as well as on the basis of the connected graph of the system, by applying Kirchhoff's laws to its nodes.

A promising approach in modeling the dynamics of mechatronic systems is the approach, which consists in the fact that the dynamics of an executive mechanism with several degrees of freedom in the space of generalized coordinates is represented as dynamics depicting points in Riemannian space (manifolds are differentiated, in which the tangent space at each point is finite-dimensional Euclidean space).

The dynamics of mechatronic systems and complexes is usually described by nonlinear differential equations. The application of effective methods of analysis and synthesis, developed in the theory of linear automatic control systems, involves the linearization of dynamics equations [4]. For its part, a linear model of system dynamics can be presented in the form of a structural-dynamic diagram. In other words, in the form of a limited set of linear dynamic links, combined into a general structure with the help of direct and feedback links. Computer analysis and synthesis of automatic control systems, which is carried out on the basis of the representation of system dynamics by structural-dynamic schemes, has developed intensively since the 70s of the last centuries and is currently quite widespread (special software complexes Simulink, VisSim and others). The significant results obtained in this direction are a package of DSD (Dynamic Systems Design) programs [3].

A number of tasks of designing mechatronic systems having spatial mechanisms with a large number of degrees of freedom, or controlling their motion, can be solved without compiling and integrating a complex system of equations. At the same time, we can limit ourselves to the study of invariants of the mechanical part (work of generalized forces on small displacements, kinetic energy) using the tensor-geometric method [4].

One of the directions of scientific research in mechatronics is the development of general theoretical provisions, on the basis of which it is possible to create effective methods of mathematical modeling of mechatronic systems and simulation automation algorithms. Since the properties of the control object, executive drive and information system must be considered in a complex and taken into account already at the early stages of designing a mechatronic system, it is necessary to develop dynamics models of both mechanical and electrical subsystems using a single method. At the same time, the method of mathematical modeling of the dynamics of a mechatronic system should have the following properties [3]:

– invariance to the physical nature of the simulated objects;

– the formality of the actions performed during the implementation of the method;
– convenience of calculation results for analysis and use in design.

Manipulator robots, mobile robots, multi-coordinate NPC machines, etc. have spatial actuators that can have a large number of degrees of freedom and contain closed kinematic loops. This complicates the mathematical modeling of the dynamics of such mechatronic systems. Multi-stage transmission mechanisms of drives, for their part, represent known difficulties in modeling dynamics, since they have significant deviations from ideal mechanical transmission, such as inertia, elastic compliance of links, backlash, and dry friction in kinematic pairs. In some cases, the mechanical part of the machine can be a non-holonomic system (with the presence of differential non-integrated connections). Therefore, the method based on the algorithms for the automated formation of models of the dynamics of mechatronic systems should have a commonality sufficient to account for all the listed factors.

Creating mathematical models of the dynamics of multidimensional systems consisting of physically heterogeneous functional parts is a time-consuming and science-intensive task. To solve it under conditions of strict time constraints, effective and maximally full use of the capabilities of modern means of automating calculations is necessary. The new possibilities of hardware and software tools for automating calculations include:

– high computing power;
– automation of creating spatial and geometric models (computer graphics);
– automation of mathematical calculations in symbolic form (computer algebra);
– developed systems of information exchange between software modules of different purposes;
– free access of project participants to intermediate design results, the possibility of prompt use of previously obtained results in the development of new projects;
– accessibility to a wide range of users, visualization and animation of simulated objects and processes.

According to the task, the automation of the simulation of the dynamics of the mechatronic system consists of:

– in the analysis of the existing methods of dynamics and justification of the choice of the method, on the basis of which the mathematical support of the software module for the automated formation of the dynamics model of the mechatronic system will be developed;
– in the development of mathematical, algorithmic and software, focused on the possibilities of modern means of automating calculations.

Today, there are five methods of obtaining the dynamics equations of multi-link executive mechanisms [1–3]:

– the Lagrange method, based on the Lagrange equations of the II kind and the description of the kinematics of the system by matrices of homogeneous coordinate transformations;
– the modified Lagrange method, based on the Lagrange II equations of the kind and the recurrent description of the kinematics of the mechanical system;

– Euler's method, based on the application of the second law of dynamics and D'Alembert's principle;

– the Gaussian method, based on the principle of least forcing;

– method of connected graphs.

Lagrange's method and Euler's method are considered traditional and are most often used in practice. The derivation of the equations of motion of holonomic mechanical systems by the Lagrange method is distinguished by the simplicity and unity of the approach, and the equations obtained by this method provide a description of the dynamics and can be used to develop control laws in the space of attached variables [3]. Expressions for the kinetic and potential energy of the links can be written relative to the coordinates of the links in a fixed coordinate system. The advantage of the Lagrange method makes it possible to use it to derive the equations of motion of mechanical systems containing closed loops. As already mentioned, the dynamics equation in Lagrange form can be formulated for an electrical system. Equations and algorithms of manipulator robot dynamics based on the application of the Lagrange method [1–3].

The application of Euler's method leads to a system of direct and inverse recurrent equations, successively applied to the links of the mechanical system. This method is the most effective from a computational point of view, which allows you to use it for real-time control of the system and for simulating its movements on a computer [3]. The advantage of Euler's method is also the ability to calculate forces and moments of reaction forces in kinematic pairs of the mechanism. From an analysis point of view, recurrence relations are not convenient. Therefore, Euler's method is practically not used in problems of synthesis of control laws.

The modified Lagrange method makes it possible to obtain the dynamics equation in a vector-matrix form, which is convenient for analysis. In addition, these equations provide a reduction in computational costs for calculating dynamic coefficients compared to Lagrange equations. With the use of coefficients, it is possible to distinguish dynamic effects due to the rotational and translational movement of links. This must be used during control synthesis in the state space of systems. The computational efficiency of these equations is due to the use of rotation matrices and relative position vectors to describe the kinematics of links. The use of the modified Lagrange method for the analysis of systems containing closed kinematic loops is associated with difficulties, because this method involves recurrent computational procedures.

The method based on the Gauss principle, in contrast to the methods based on the Lagrange equations, makes it possible to obtain the dynamics equations of mechanical systems, both with holonomic and non-holonomic couplings. When using the Gaussian principle, the task is reduced to determining the accelerations of the true motion, which provide a minimum expression for forcing. This is achieved by numerically minimizing the forcing as a function of the generalized accelerations of the mechanical system using dynamic programming or uncertain Lagrange multipliers. An undoubted advantage of the Gaussian method can be considered the possibility of its application to study the movement of mechanical systems with unregulated connections. The advantage of the Gaussian method is achieved precisely in those cases when numerical methods are used to minimize the forcing at each step of the integration of the dynamic's equations.

The method of connected graphs is based on the presentation of a system (mechanical, electrical, hydraulic or combined) in the form of some finite number of elements that have a formal mathematical description and are connected to each other in a general structure by means of connections. This method is the result of the development of graph theory, one of the founders of which was L. Euler.

The mathematical model of system dynamics is displayed in the form of a diagram (graph), on the basis of which the dynamics equations are derived, while the mechanical part of the system can be non-holonomic. The main advantage of the method of connected graphs is the structural-graphic representation of the dynamics of the studied systems, which makes it possible to trace all the interactions of the system elements visually and obtain the dynamics equation by applying Kirchhoff's simple laws to the connected graph. The use of the method of connected graphs gives the greatest effect in the description, analysis and design of branched systems with the presence of closed kinematic contours.

Therefore, the method of connected graphs is adopted as the theoretical basis of equations and algorithms for automated modeling of the dynamics of mechatronic systems.

References

1. Попович М.Г. Електромеханічні системи автоматичного керування та електропривод. Київ : Либідь, 2005. 678 с.

2. Яглінський В.П. Моделювання динамічних процесів роботизованого виробництва. Одеса : АстроПрінт, 2004. 234 с.

3. Bishop R.H. The Mechatronics Handbook. Boca Raton : CRC Press, 2002. 1229 p.

4. Onyshchenko S. Design of Mechatronic Industrial Systems. *World science : problems, prospects, innovations : Materials of the IV International research and practical internet conference (October, 20, 2023) : collection of abstracts* // for the general ed. Ph.D Serhii Onyshchenko. Zdar nad Sazavou : "DEL c.z.", 2023. P. 17–18.

5. Onyshchenko S. Formation of Ict-Competence of the Future Specialist in the Energy Industry in the Conditions of Informatization of Education (Distance Education). *The latest foundations for the development of production, science and education – 2023 : collective monograph.* Nová Dubnica : NES Nová Dubnica s.r.o., 2023. P. 37–55. https://dspace.bdpu.org.ua/handle/123456789/118

6. Onyshchenko S. Psychological and Pedagogical Foundations of the Application of Modern Information Technologies in the Educational Process of Future Specialists in the Energy Industry. *European vector of modern education, science and production – 2023 : collective monograph.* Nová Dubnica : NES Nová Dubnica s.r.o., 2023. P. 57–73. https://dspace.bdpu.org.ua/handle/123456789/117

7. Onyshchenko S. Structure of Information Competence of Future Engineers-Educators. *Development of the educational system : European vector : Materials of the IV International research and practical internet conference (September, 15, 2023) : collection of*

abstracts / for the general ed. Ph.D Serhii Onyshchenko. Zdar nad Sazavou : "DEL c.z.", 2023. P. 17–19. https://dspace.bdpu.org.ua/handle/123456789/1116

8. Onyshchenko S. Theoretical Analysis of the Independent Work of Future Engineers-Pedagogues in the Teaching of Professionally Oriented Disciplines in Higher Education Institutions. *Modern conditions of development of science, education and production in the world – 2023 : collective monograph.* (Series of monographs Slovak publishing house NES Nová Dubnica s.r.o. Monograph 1). Nová Dubnica : NES Nová Dubnica s.r.o., 2023. P. 70–88. https://dspace.bdpu.org.ua/handle/123456789/732

2.2. Inna Marynchenko TRAINING OF VOCATIONAL EDUCATION TEACHERS TO WORK IN AN INCLUSIVE EDUCATIONAL ENVIRONMENT

Over the past decades, solving the issue of teacher readiness for professional adaptation in an inclusive environment in higher education institutions of Ukraine has become one of the most important social problems of the country's society. In this context, it becomes urgent to solve the problems of implementing the components of the teacher's readiness and the pedagogical conditions of his adaptation in an inclusive educational environment, as well as increasing the level of their socio-pedagogical competence. The relevance of the scientific topic is based on solving the problems of the methodology system of training teachers of vocational training to work in an inclusive educational environment, increasing the level of their inclusive competence, the peculiarities of the organization of a favorable inclusive environment in the student group, which involves the implementation of the educational process on the basis of mutual assistance and mutual assistance.

Keywords: inclusion, index of inclusion, socio-pedagogical competence, components of readiness, pedagogical conditions, inclusive educational environment.

2.3. Yuliia Meish, Mariia Meish STUDY OF THE INFLUENCE OF PERFECTIONISM AND PROCRASTINATION ON PERFORMANCE INDICATORS OF STUDENTS AND TEACHERS

The work examines the concepts of procrastination and perfectionism in the field of education. The problem of procrastination is becoming serious and expanding in the education sphere due to the growing requirements for the efficiency and productivity of educators. The negative consequences of procrastination are expressed both in a significant decrease in a person's work capacity and inability to further develop in the professional environment, and in emotional experiences of failure, guilt for untimely completed tasks, and dissatisfaction with work results. The problem of perfectionism is no less significant in the context of efficiency, as the pursuit of the ideal often leads to increased demands in training and work and, as a result, to a decrease in efficiency and speed.

Keywords: perfectionism, procrastination, performance indicators.

CHAPTER 3. Serhii Onyshchenko ELECTROMECHATRONIC COMPLEXES AND MODULES

The priority direction of the development of science and technology at the current level is the development, creation and implementation of mechatronic systems of the new generation.

Currently, the development of the industrial and household technosphere and the further implementation of mechatronic automation and robotics systems in various physical and technical processes of all spheres of society contribute to the creation of intelligent physical and technical products, systems and processes that have qualitatively new functions, properties and capabilities.

On the basis of technical achievements in the fields of mechanics, automation, electronics and informatics, the structure of creation of electromechatronic systems, which affect the operation of automated control of machines and mechanisms, is carried out.

Keywords: mechatronics, system, complex, module, electromechatronics.

CHAPTER 4. INNOVATIONS IN MODERN MEDICINE AND BIOLOGY

4.1. Sofiya Vasylyuk, Nataliya Monka, Ihor Franiv PROJECT INNOVATIONS IN BIOPHARMACY, BIOMEDICINE AND ENVIRONMENTAL PROTECTION

The development of biopharmaceutical and biomedical technologies contributes to the implementation of global national policies of a healthy lifestyle and development, as it has an important impact on solving the main problems related to human survival and development. Constantly innovating to improve efficiency and promote sustainability, environmental biotechnology is also extremely important for the protection of biodiversity (plants, animals and humans). Such directions as reducing emissions of industrial waste, preventing and cleaning pollution, mitigating the consequences of climate change will continue to attract significant attention of researchers. In view of the outlined prospects for the development of biopharmaceutics, biomedicine and ecological biotechnology, initiatives supporting biotechnological innovations are being promoted around the world.

Keywords: biomedicine, bioeconomy, biotechnology, environmental protection innovations.

CHAPTER 5. SCIENTIFIC VIEWS ON LAW AND HISTORY

5.1. Oleg Morozov HISTORICAL AND LEGAL ASPECTS OF THE FIGHT AGAINST SMUGGLING ON THE TERRITORY OF UKRAINE: FROM ANTIQUITY TO THE END OF THE XXtn CENTURY

The scientific publication examines the historical, legal, and social aspects of the historical evolution of smuggling on the territory of Ukraine in different historical periods: from the time of the Roman Empire to the end of the 1980s. It analyzes how the legal systems of various formations responded to this type of offense. An important place is given to the statistics of customs offenses in different historical periods, which allows us to determine the main trends in the evolution of smuggling. The considered legal policy of state bodies is aimed at combating smuggling.

Keywords: history, smuggling, customs duty, foreign trade, crime.

ABOUT THE AUTHORS

CHAPTER 1. MODERN BASICS OF ECONOMICS, MANAGEMENT AND TOURISM

1.1. Lidiya Lisovska – Doctor of Economics, Professor, Lviv Polytechnic National University, Ukraine

Oleh Karyy – Doctor of Economics, Professor, Lviv Polytechnic National University, Ukraine

Maryana Gvozd – PhD in Economics, Associate Professor, Lviv Polytechnic National University, Ukraine

1.2. Roman Miroshnyk – Ph.D, Associate Professor, Lviv Polytechnic National University, Ukraine

Iryna Bahlai – Ph.D, Associate Professor, Lviv Polytechnic National University, Ukraine

CHAPTER 2. INNOVATIVE AND MODERN FOUNDATIONS OF PEDAGOGY AND PSYCHOLOGY

2.1. Wang Yixuan – PhD student, Educational, pedagogical sciences Doctoral students, Lviv Polytechnic National University

2.2. Inna Marynchenko – Candidate of Pedagogical Sciences, Associate Professor, Head of the Department of Vocational Education and Computer Technologies, Oleksandr Dovzhenko Gluhiv National Pedagogical University, Ukraine

2.3. Yuliia Meish – Doctor of Technical Sciences, Professor, Professor Department of Higher and Applied Mathematics, National University of Life and Environmental Sciences of Ukraine

Mariia Meish – Student Faculty of Economics, Department: Marketing and Business Management, National University of Kyiv-Mohyla Academy

CHAPTER 3. THEORETICAL ANALYSIS OF THE INDEPENDENT WORK OF FUTURE ENGINEERS-PEDAGOGUES IN THE TEACHING OF PROFESSIONALLY ORIENTED DISCIPLINES IN HIGHER EDUCATION INSTITUTIONS

3.1., 3.2., 3.3., 3.4. Serhii Onyshchenko – PhD, Associate Professor, Berdyansk State Pedagogical University

CHAPTER 4. INNOVATIONS IN MODERN MEDICINE AND BIOLOGY

4.1. Sofiya Vasylyuk – Doctor of science, Associate professor, Professor of Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, Ukraine

Nataliya Monka – PhD in Chemistry, Associate professor of Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, Ukraine

Ihor Franiv – Doctor of science, Professor, Head of Department of Entrepreneurship, Trade and Logistic, Lviv University of Trade and Economics, Ukraine