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SPECIFIC METHODS FOR THE DEVELOPMENT AND CONDUCT OF AUDITORIUM LESSONS IN ROBOTIC DISCIPLINES

СПЕЦІАЛЬНІ МЕТОДИКИ РОЗРОБКИ ТА ПРОВЕДЕННЯ АУДИТОРНИХ ЗАНЯТЬ З РОБОТОТЕХНІЧНИХ ДИСЦИПЛІН

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Abstact. *New regulatory requirements for the system of higher education in Ukraine require the introduction of innovative approaches to the content and organization of the educational process. In this regard, the training of competent specialists in robotics requires updating the forms, methods and means of conducting classroom classes. At the same time, there is a need for changes in traditional education, the creation of a new methodical system, where the leading role is given to the practical implementation of theoretical knowledge, and the making of project-technical and configuration decisions. For this purpose, it is expedient to create methodological support for the teaching of educational disciplines of professional robotics with the help of a multi-level functional teaching system. It may be promising to build a complex of models, the relationships between which are established in a constructive way, organizing them into one system with ensuring the transition from one to the other. Interdisciplinary connections ensure the resolution of contradictions between the acquired knowledge from different disciplines and the need for their integration, as well as the practical application of the totality of this knowledge. To teach the disciplines of the robotics complex, it is advisable to use certified educational laboratory stands for conducting classes in several disciplines and make constructively organized connections between them.*

Keywords: *robotics, methodical support, professional competence, the complex of models, laboratory stand, constructive connections, interdisciplinary connections.*

Introduction

Currently, there is an active development of the machinery industry and the widespread introduction of robotics in almost all technological processes of production. In this regard, the society needs competitive specialists in robotics, who must be able to perceive, generate, and practically implement new scientific ideas, develop and use technical devices, software, and data management applications. Possession of professional knowledge and skills and their effective use in professional activities are of great importance for future engineers, which is one of the directions of modernization of education in Ukraine. The new regulatory requirements for the higher education system, outlined in the legislative documents of Ukraine [1,2], set scientists and educators the task of implementing innovative approaches to the content and organization of the educational process, namely, updating the forms, methods and means of conducting lessons.

Taking into account the fact that the technical component occupies a significant place in the professional training of engineers, there is a need to develop a methodical system of their technical training, where the leading role is given to the practical implementation of theoretical knowledge, making of engineering, designing and configuration decisions.

Currently, there is an active search, development and implementation of innovative learning technologies, which is evidenced by numerous international and domestic scientific and methodical publications [3-7]. Researchers M. Korets [8] and S. Yashchuk [9] highlighted the methodological foundations and practical ways of studying general technical disciplines in their works.

Therefore, the effective training of future robotics specialists at the current stage of the development of the educational process consists in outlining, in accordance with the requirements of the modern labor market, goals and objectives, organizational training methods and means. In connection with the rapid development of modern innovative educational technologies, there is a need to change traditional education, to create a new methodical system. Despite the fact that scientists and teachers pay considerable attention to the engineering training of specialists, currently there is a lack of scientific research that would provide methodological support for the specific professional orientation of engineers throughout the entire period of study in higher education, which, in our opinion, can be carried out by creating multi-level functional system of teaching technical disciplines.

The purpose of this research is to create methodical support for the teaching of educational disciplines of a professional orientation with the help of a multi-level functional system of teaching technical disciplines, as a result of which the technical thinking of the functioning of robotic systems for scientifically based practical activities is formed.

The results of the research

Methodical support for the formation of the professional and methodical orientation of future engineers should be carried out as a multifunctional, multi-component, information-electronic-oriented process, which includes: professional growth, self-improvement; formation of a professional focus by mastering digitalized and distance courses in technical disciplines; interaction of participants in the educational process throughout the entire period of study. These measures can be ensured by determining the optimal means, forms, methods and means that are effective in the organization of training and ensure the proper level of formation of general and professional competencies. The effectiveness of the learning process fully depends on the correct choice of teaching methods and the logic of their application.

The training methodology is based on the following principles: adequacy, technicality, integrativeness, professional and scientific orientation, which provide the possibility of forming a high level of technical competence of future robotics specialists who are able to improve their professional skills, implement the process of innovation in their professional activities, and quickly adapt to changes [10]. Achieving of this goal involves the following tasks: the formation of intellectual and personal qualities that determine the motivation of the future specialist to carry out engineering activities [11].

Motivational incentives to carry out such activities are formed when studying the basics of the disciplines: "Machine parts", "Theoretical and computational mechanics", "Electrical engineering, electronics and microprocessor engineering", "Hydraulics, hydraulic and pneumatic drives", "Fundamentals of designing robotic systems" and "Electric drives of robots". This leads to development of a system of knowledge in technical disciplines, skills and abilities to work with hardware devices, beliefs and value ideas about the role of computer technology in modern society, the formation of which makes it possible to effectively implement the technical component of one's professional activity.

The technical competence of the future specialist should be formed as a result of the implementation of interrelated processes: their acquisition of technical and technological knowledge, abilities and skills and the development of professionally important qualities of the individual, and also through the involvement of microelectronic devices, as one of the major directions of modern fundamental science, in all types of classes [12].

It may be promising to build a complex of models that describe different disciplines, as well as design aimed at creating such models, using certain experience in teaching different disciplines [13].

Models can be used individually or in groups. Relationships between models are established in a constructive way. When knowledge relates to relevant models, and the models are constructively connected, connections are established between knowledge that organize them into one system and enable the transition from one to another. Interdisciplinary connections ensure the resolution of contradictions between the acquired knowledge from different disciplines and the need for their integration, as well as the practical application of the totality of this knowledge [14].

In our opinion, for teaching the complex of disciplines related to robotics, it is advisable to use certified educational laboratory stands to be used to conduct classes in several disciplines and make constructively organized connections between them.

Let us consider the characteristics of the laboratory stand НТЦ-11.36.1 “Hydraulic machines and drives M2” and prove the expediency of its use in educational activities.

On the frame supporting structure of the stand, made in the form of a one-sided base with a table, there are three panels intended for mounting of:

– hydraulic equipment;
– devices for measuring pressure, flow and temperature;
– devices for control and electrical measurements.

The hydraulic circuit is located on the last (third) panel. The stand has a rigid configuration but permits some additional assembly operations to be performed considering the specificity of a laboratory session. The stand includes two hydraulic power units. The stand is equipped with:

– two three-phase electric motors;
– three gear pumps, two hydraulic cylinders;
– one axial-piston non-adjustable hydraulic motor;
– two hydraulic pressure valves;

– three hydraulic distributors with electromagnetic control;
– two two-line flow regulators;
– two adjustable chokes and a filter;
– mounting plates;
– connecting fittings and pipelines;
– three-line flow controller.

Owing to the three-phase power supply system, it is possible to determine with high accuracy the power supplied to the main pump of the stand and methodically correctly obtain the operating and cavitation characteristics of the pump, as well as determine the efficiency of the hydraulic drive during translational and rotational movement of the output links.

When testing hydraulic drives and hydraulic motors, it is possible to change the speed of movement of the output links and the load on them in a wide range.

When selecting the hydraulic devices of the stands, coordination of their pressure and flow characteristics is ensured, which allows conducting experimental studies of various modes, including nominal ones.

The information and measurement system of the stand provides determination of pressure (eight pressure gauges and one vacuum gauge are installed on the stand), flow rates (the stand includes two flow meters: volumetric type – for measuring the flow rate of internal leaks and speed type), temperature of the working fluid, power supplied to the main pump, power at the output links (cylinder and hydraulic motor), revolution rate of the shafts of the main pump and hydraulic motor.

Rotation rates are measured with electronic frequency meters. The stand also includes an electronic stopwatch. Software and methodical support are added to the laboratory stand: a set of methodical and technical documentation intended for the teaching staff.

With this stand, the following laboratory works can be carried out.

1. Study of the device and determination of operational and cavitation characteristics of the gear pump.
2. Study of the device and determination of the characteristics of the axial-piston non-regulated hydraulic motor.
3. Study of the device and determination of hydraulic cylinder characteristics.
4. Study of the characteristics of a controllable volumetric hydraulic drive with translational movement of the output link (controlled by a throttle).
5. Study of the characteristics of a controllable volumetric hydraulic drive with rotational movement of the output link (controlled by a throttle).
6. Study of the effectiveness of the use of two- and three-line flow regulators in an controllable hydraulic drive.

The mentioned laboratory stand НТЦ-11.36.1 “Hydraulic machines and drives M2” is advisable to use when conducting classes in the disciplines: "Electrical engineering, electronics and microprocessor engineering", "Fundamentals of designing robotic systems" and "Electrical drives of robots".

We will consider the characteristics of the laboratory stand НТЦ-10.67 "Distribution networks of power supply systems with MPSZ" NTC-10.67 and prove the expediency of its use in educational activities.

Structurally, the stand consists of a case in which part of the electrical equipment, a microprocessor measuring system, a front panel and an integrated workbench are mounted.

In the casing of the stand there are:

- step-down transformers;
- a thyristor voltage regulator board (TVR);
- a set of load resistors;
- a set of capacitors;
- inductors used as chokes;
- a unit of incandescent lamps ~220 V 15 W, 15 lamps;
- power autotransformer based on OSM1-0.1;
- microprocessor measuring system module; which provides multi-channel measurement in all three phases with the output of measured current and voltage values on digital indicators.

The set of measured parameters is sufficient for effective studying of processes in electric power systems without connecting the stand to a computer. By connecting the stand to the computer (via USB) and using the supplemented software, it is possible to display oscillograms of currents and voltages in each of the three phases in static and transient processes. This significantly increases the quality and depth of knowledge acquired by students during laboratory classes.

The front panel shows electrical diagrams of the objects of study. All the circuits depicted on the panel are divided into groups according to the subject of the work to be conducted. On the panel, are installed switching sockets, switching equipment, as well as control bodies that allow alterations of the parameters of the elements studied during laboratory work.

Controls on the front panel of the stand:

- the switch of the incandescent lamp unit (the load of the circuits) for setting different modes of operation of the investigated 3-phase network;
- toggle switches of the bank of capacitors for changing the capacitance in the range from 0 to 31 μF with a step of 1 μF;
- setting potentiometer of the TVR.

To carry out the work, it is necessary to assemble the circuit of the research object with the help of unified jumpers, which ensure that the assembled circuit can be clearly observed.

Conducting laboratory work is possible both in manual mode and in the mode of interaction with a personal computer. It is possible to assemble circuits of one’s own design using jumpers of different lengths and connecting required points of the circuit to the measuring channels of the microprocessor measuring system.

The laboratory stand is supplemented with software and methodological support:

- student testing program for admission to laboratory work. In the testing process, both theoretical knowledge and knowledge of the content of the performed laboratory work are checked. As a result of testing, the student receives a knowledge assessment;
- software of the measuring complex;

– a set of methodical and technical documentation intended for teaching staff.

The software enables the following actions:

- to display up to 21 measurement channels in one plot, with individual adjustment of scale parameters of the vertical axis for each of the channels and general adjustment of scale parameters of the horizontal axis for all channels;
- to build Lissajous figures for any two measuring channels;
- to perform spectrum analysis of any of the measurement channels used;
- to measure the signal frequency on any channel used;
- to calculate active, reactive power components, full power and power factor;
- to save the array of data from the buffer for further analysis;
- to export oscillograms in graphic formats;
- to set the parameters of the DAC for generation of sinusoidal, triangular and rectangular signals.

With the stand, the following laboratory works can be conducted:

1. Measurement of transformer operating mode parameters.
2. Measurement of power transmission line operating mode parameters.
3. Measurement of operating mode parameters of an open distribution electrical network.
4. The influence of reactive power compensation with the help of a capacitor bank on the operating mode parameters of an open distribution electric network.
5. Study of the static characteristic of the power of the capacitor bank.

The specified NTC-10.67 laboratory stand is advisable to use when conducting auditorium lessons in the following disciplines: "Electronics and automation devices", "Information devices of mechatronic systems", "Interchangeability, standardization and technical measurements".

Conclusions

To assess the level of development of the technical skills of future robotics engineers, we have developed and applied a system of interdisciplinary project-type courses that are practical in nature, contribute to the consolidation and deepening of the acquired technical knowledge, and expand the worldview of students.

The use of any industrial equipment during lectures to demonstrate the work process, its consequences and characteristics of various types of technologies also improves the assimilation of classroom material during the teaching of both general technical and special disciplines.

During the teaching of the lecture material, it is also possible to demonstrate stands, mock-ups, and operating equipment. In order to make the above possible, it would be desirable for general technical and graduation departments to have agreements on creative cooperation with relevant enterprises of the industry.

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Анотація. *Нові нормативні вимоги до системи вищої освіти в Україні потребують впровадження інноваційних підходів до змісту та організації навчального процесу. У зв'язку з цим підготовка компетентних спеціалістів з робототехніки потребує оновлення форм, методів і засобів проведення аудиторних занять. Водночас виникає необхідність змін у традиційній освіті, створення нової методичної системи, де провідна роль відводиться практичній реалізації теоретичних знань, прийняттю проектно-технічних і конфігураційних рішень. З цією метою доцільно створити методичне забезпечення викладання навчальних дисциплін професійної робототехніки за допомогою багаторівневої функціональної системи навчання. Перспективним може бути побудова комплексу моделей, взаємозв'язки між якими встановлюються конструктивно, організовуючи їх в одну систему із забезпеченням переходу від однієї до іншої. Міжпредметні зв'язки забезпечують розв'язання протиріч між набутими знаннями з різних дисциплін і необхідністю їх інтеграції, а також практичне застосування сукупності цих знань. Для викладання дисциплін робототехнічного комплексу доцільно використовувати атестовані навчальні*

лабораторні стенди для проведення занять з кількох дисциплін та конструктивно організовувати зв'язки між ними.

Ключові слова: *робототехніка, методичне забезпечення, професійна компетентність, комплекс моделей, лабораторний стенд, конструктивні зв'язки, міжпредметні зв'язки*

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