Syllabus
Course Program

Flexible Manufacturing Systems

Specialty
131 – Applied Mechanics

Institute
Institute of Education and Science in Mechanical Engineering and Transport

Educational program
Applied Mechanics

Department
Department of Mechanical Engineering Technology and Metal-Cutting Machines (146)

Level of education
Bachelor's level

Course type
Special (professional)

Semester
8

Language of instruction
English,

Lecturers and course developers

Yevheniia Basova

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Academic degree, academic title, position

Candidate of Engineering Sciences, 05.02.08 - manufacturing engineering. Associate Professor of the Department of Mechanical Engineering Technology and Metal-Cutting Machines. Author of more than 30 scientific and educational works, h-index (Scopus) = 10. Member of the international scientific conferences “The International Conference of Reliable Systems Engineering - ICoRSE”, " Design, Simulation, Manufacturing: The Innovation Exchange", Innovation in Engineering-ICIE”, " Automation and control in theory and practice". Member of the editorial board (Associate Editor) of the journal International Journal of Mechatronics and Applied Mechanics – IJOMAM e-ISSN: 2559-6497, https://ijomam.com/ (included in SCOPUS, EICompendex, EBSCO, and ProQuest international databases (IDB)). Lecturer in the following disciplines: " Flexible Manufacturing Systems", "Fundamentals of CAD", " Technologies for Repair and Model Details Processing", "Automatic lines in mechanical engineering".
More about the lecturer on the department's website

General information

Summary

The course will provide students with an understanding of the basic definitions of flexible automated manufacturing and its role in ensuring sustainable development of the engineering industry. Students will learn the principles of using and creating flexible systems using industrial robots and manipulators, technological equipment, modern digital technologies and services in accordance with the Industry 4.0 concept. In the course of training, students will acquire skills in the peculiarities of design and calculation of modern robotic complexes designs, their layout and structures, characteristics and requirements, conditions of application of various Industry 4.0 technologies for the transformation of industrial production (digital twins, modelling, additive technologies, augmented reality, IoT and others).

Course objectives and goals

To form students' knowledge of modern platforms of flexible automated production. The student should be able to evaluate flexible production systems by economic and production indicators, design flexible production systems at the level of robotic technological complex and taking into account the principles of Lean transformations, carry out calculations related to the design of robotic technological complexes and other flexible production systems with the involvement of various Industry 4.0 technologies.

Format of classes

Lectures, laboratory work, independent work, consultations, conversation, discussions, narrative, shows, demonstrations, independent work, generalisation and classification of the received information, etc. The final control is an test

Competencies

ЗК01 Ability to think abstractly, analyse and synthesise.
ЗК02 Knowledge and understanding of the subject area and understanding of professional activities.
ЗК03 Ability to identify, pose and solve problems.
ЗК04 Ability to apply knowledge in practical situations.
ЗК05 Ability to work in a team.
ЗК06 Determination and persistence in relation to tasks and responsibilities.
ЗК07 Ability to learn and acquire up-to-date knowledge.
ЗК09 Skills in the use of information and communication technologies.
ЗК10 Skills to carry out safe activities.
ЗК11 Ability to act in a socially responsible and conscious manner.
ЗК12 Ability to search, process and analyse information from various sources.
ЗК13 Ability to assess and ensure the quality of work performed.
ЗК15 Ability to preserve and increase moral, cultural, scientific values and achievements of the society on the basis of understanding the history and regularities of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, engineering and technology, to use various types and forms of motor activity for active recreation and healthy lifestyle.
ФК01 The ability to analyse materials, structures and processes on the basis of laws, theories and methods of mathematics, natural sciences and applied mechanics.
ФК02 The ability to assess the performance parameters of materials, structures and machines in operational conditions and find appropriate solutions to ensure a given level of reliability of structures and processes, including in the presence of some uncertainty.
ФК03 The ability to carry out technological and technical-economic evaluation of the efficiency of new technologies and technical means.
ФК07 Ability to use computer-aided design (CAD), manufacturing (CAM), engineering research (CAE) systems and specialised application software to solve engineering problems in applied mechanics.
ФК08 Ability to think spatially and reproduce spatial objects, structures and mechanisms in the form of projection drawings and three-dimensional geometric models.
ФКс3.2 Ability to use information technologies in engineering activity.
ФКс3.4 Ability to apply methods and means of mechanisation and automation of production processes.
ФКс3.5 Ability to provide skills to work with computer-aided design systems of various geometrical objects and mechanisms used in technological sphere.
ФКс3.6 Ability to select the necessary technological equipment for machine-building production, to justify and determine expedient transport and storage systems of sections and workshops.

Learning outcomes

PH01 Select and apply suitable mathematical methods to solve problems in applied mechanics
PH05 Perform geometrical modelling of parts, mechanisms and structures in the form of spatial models and projection images and draw up the result in the form of technical and working drawings.
PH07 Apply normative and reference data to check the conformity of technical documentation, products and technologies to standards, specifications and other normative documents.

РН08 Know and understand the basics of information technology and programming, and practically use application software to perform engineering calculations, process information and experimental results.
ПРН3.03 Know the specifics of using information technology in engineering activities.
ПРН3.04 Know the methods and means of mechanisation and automation of production processes.
ПРН3.06 Know the technological equipment of machine-building industries.
ПРН3.11 Know the structure and methods of designing technological processes for manufacturing parts using automated systems for technological preparation of production. Know the features of using automated equipment and automatic lines in the manufacture of machine-building products.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 30 hours, laboratory classes - 10 hours, practical classes 10 hours, self-study - 70 hours.

Course prerequisites

For successful completion of the course it is necessary to have knowledge and practical skills in the following disciplines: "Ecology", "Descriptive geometry, engineering and computer graphics", " CAD Fundamentals ", " Technological Fundamentals of Machinebuilding ", " Fundamentals of Occupational Safety and Health ", " Enterprise Economics ", " Interchangeability, Standardization and Technical Measurements in Mechanical Engineering ", " Computer Technologies in Machine Engineering", " Technology of Aided Engineering Production ".

Features of the course, teaching and learning methods, and technologies

Teaching methods:
- Learning project, which is conceptualised as "learning by doing" is applied mainly in practical works (less often in lectures). Application of the method involves providing students with a sufficiently wide range of projects to realise the possibility of real choice. It should be noted that projects can be both individual and collective. The latter, among other things, contribute to the student's mastery of collective methods of work. In order to master the project method of work, the student is provided with instructions on how to work on the project (methodological guidelines). Each educational project involves the production of a final result using a handy material on the topic of work, the results of which become a reference for the final assessment. Collective discussion of difficult moments in solving a task forms a field of collective work and is a positive experience for both the student and the teacher.
- The project method is oriented mainly on mastering the techniques of working with GIS. A mandatory component of the learning process is the control or verification of learning outcomes. The essence of verification of learning outcomes is to identify the level of knowledge assimilation by students, which should correspond to the educational standard of the discipline.
- Explanatory-illustrative method, involving the use of visual lecture material in the form of tables, posters, presentations made in MS Power Point environment.
- Reproductive method, which is used when performing practical work and solving standard tasks.
- The method of stimulation and motivation of learning is applicable when encouraging students to independently study the discipline materials (the possibility of receiving motivational extra points for active work in the classroom, in the preparation of reports or advance performance of calculation tasks).
- Methods of control and self-monitoring, providing for the verification of current knowledge by instant polls or short tests at the beginning of the class, as well as planned modular control.
Mastering the discipline provides for constant contact between the teacher and the student through conversation, lecture, storytelling, demonstrations, demonstrations, LS, independent work, generalisation and classification of the received information, etc.

Program of the course

Topics of the lectures

Topic 1 Introduction to flexible manufacturing systems
Stages of automation development. Basic prerequisites for the creation of flexible manufacturing systems. Terms and definitions of flexible manufacturing systems. Flexible manufacturing systems and Industry

4.0. Factory of the future: "Industry 5.0" for the organisation of fault-tolerant flexible manufacturing systems.
Topic 2: Flexible Production Systems and Lean Production Principles
Selection of objects of flexible automated production. Designing of technological processes for manufacturing of products. Using digital twins and simulation tools to optimise manufacturing processes. Principles of Lean manufacturing and their role for FMS.
Topic 3: Technical and technological solutions for FMS.
Technological foundations of flexible manufacturing systems. Means of technological equipment of flexible production systems. Selection and design of machine tool constructions.
Topic 4. Systems for ensuring the functioning of hot water supply and cyber-physical production systems.
Classification and selection of the structure of an automated transport and warehouse system. Selection and classification of automated tooling systems. Cyber-physical systems (CPS) and the Internet of Things (IoT) for ensuring the sustainability of the water supply system. Fundamentals of Supply chains in the water supply industry.
Topic 5. DHW and Smart Factory.
Automated control systems in the DHW sector. Automated control systems (ACS). Smart Factory philosophy on the way to sustainable development of the engineering industry.
Topic 6. Launch of new products in production in the conditions of hot water supply. Optimisation of production.
Participation of production in the product life cycle. The role of Iot, AI, ML, DFM, DTC, DFQ, DFD, prototyping, mock-ups, etc. in ensuring the sustainability of GWC. Robotic technological complexes. Development of layout solutions for flexible production systems. Productivity and efficiency of flexible production systems.

Topics of the workshops

Topic 1 Organisation of simple and complex manufacturing processes in time.
Topic 2 Organisation of flexible production process
Topic. 3. Organisation of process equipment maintenance by industrial robot
Topic 4: Selection of resource-saving technological process in accordance with the principles of Lean manufacturing.
Topic 5: Determination of economic effect from the improvement of quality indicators of the product manufactured under FMS conditions.

Topics of the laboratory classes

Topic 1 Evaluation of efficiency and flexibility of FMS.
Topic 2: Study of RTC 16K20F3RM132 with PR M10P62.01
Topic. 3. Development of the movement path of the RR M10P62.01 as part of the RTC 16K20F3RM13.
Topic 4: Development of the operation diagram, calculation of standard indicators of the RTC 16K20F3RM132 with the PM M10P62.01.
Topic 5: Development of control algorithm of RTC 16K20F3RM132 with PR M10P62.01.

Self-study

The course provides individual calculation assignment on the development of flexible manufacturing cell for the manufacture of a typical engineering part.
Students are offered a list of topics, in accordance with the object of study of the discipline, for the preparation of illustrated reports. The report (3-5 min.) provides for the creation of prerequisites for the activation of discussion (<5 min.) in the student team to collectively establish unity in the highlighted issue.

Course materials and recommended reading

1. Lecture Notes.
2. Materials provided by Advantech, Rockwell Automation, ABB Automation, Bosch Automation, Micro-Epsilon, Euresys, HART Communication Foundation, Yokogawa, Pepperl & Fuchs ", Beckhoff, ICT GmbH, etc.
3. LGN [Electronic resource]. Access mode: http://leanglobal.org/what-is-lean/.

4. Radziwona A., Bilberga A., Bogersa M., Madsenb E. The Smart Factory: Exploring Adaptive and Flexible Manufacturing Solutions. DAAAM International Symposium on Intelligent Manufacturing and Automation, Procedia Engineering 69. 2014. pp. 1184–1190
5. Pravin Jadhav, Nachiket Ekbote, Implementation of lean techniques in the packaging machine to optimize the cycle time of the machine, Materials Today: Proceedings, Volume 46, Part 20, 2021, Pages 10275-10281, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2020.12.162
6. LEAN ENGINEERING [Electronic resource]. Access mode: http://www.leanengineering.com.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

100% of the final assessment consists of assessment results in the form of an exam (30%) and current assessment (70%).
Current assessment: 2 tests (12% and 10%) and individual calculation assignment (10%), active position in discussing issues at lectures and practical classes (5%), successful completion of practical and laboratory works (20%), preparation of an individual illustrated report on a given topic (3%).
Examination: a written assignment (2 questions on theory + practical problem solving) and oral discussion..

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date, signature	Head of the department Oleksandr PERMIAKOV
	Date, signature	Guarantor of the educational program Oleksandr RUBASHKA