



Syllabus Course Program

Tooling



Specialty

131 –
Applied Mechanics

Educational program

Applied Mechanics

Level of education

Bachelor's level

Semester

7

Institute

Institute of Education and Science in Mechanical Engineering and Transport

Department

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

Course type

Free choice (professional), Selective

Language of instruction

English, Ukrainian

Lecturers and course developers



Maryna Ivanova

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Candidate of Technical Sciences. Associate Professor. Associate Professor of the Department of Mechanical Engineering Technology and Metal-Cutting Machines

Work experience - 12 years. Co-author of more than 50 scientific works, 1 monograph, and 2 training manuals. Leading lecturer in courses: Introduction to Speciality. Introductory Practice; Mechanization and automation of technological processes; Equipment and Transportation of Machining Shops, Technological Fundamentals of Machinebuilding.

[More about the lecturer on the department's website](#)

General information

Summary

The course 'Tooling' provides knowledge about the basic principles of designing technological tooling in the organisation and technological preparation of machine manufacturing, as well as typical designs, principles of operation and areas of use of various devices at all stages of machine manufacturing: processing of parts, their control and assembly of machines. During the course, students will learn how to use unified designs of fixtures, design special fixtures, as well as promising trends in the production of fixtures by leading manufacturing companies.

Course objectives and goals

To provide students with in-depth systematic knowledge of the general issues of layout, calculation and design of technological tooling for mechanical engineering production: clamping devices, tooling systems, assembly devices, measuring devices and systems. To form modern concepts and practical skills required by a mechanical engineer in the design and use of technological tooling and machine control in the process of technological preparation of mechanical engineering production.

Format of classes

Lectures, laboratory classes, practical training, self-study, consultations. The final control is an credit.

Competencies

GC01. Ability to think abstractly, analyze and synthesize
GC02. Knowledge and understanding of the subject area and understanding of professional activities
GC03. Ability to identify, pose and solve problems
GC04. Ability to apply knowledge in practical situations
GC05. Knowledge and understanding of the subject area and understanding of professional activities.
GC12. Ability to search, process and analyze information from various sources
PCs3.1 Ability to use hardware and software systems for automation of production activities
PCc3.4 Ability to apply methods and means of mechanization and automation of production processes
PCc3.8 Ability to select the type of technological tooling, carry out design and development work and organize its production

Learning outcomes

LO01 Select and apply suitable mathematical methods to solve problems of applied mechanics
LO03 Perform calculations on the strength, endurance, stability, durability, stiffness of machine parts
LO05 Perform geometric modeling 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
LO06 Create and theoretically substantiate the design of machines, mechanisms and their elements on the basis of methods of applied mechanics, general principles of design, theory of interchangeability, standard methods of calculation of machine parts
LO07 Apply normative and reference data to control the compliance of technical documentation, products and technologies with standards, specifications and other regulatory documents
PLO3.04 Know the methods and means of mechanization and automation of production processes
PLO3.05 Know the basics of creating and using automated systems design of various geometric objects and mechanisms
PLO3.06 Know the technological equipment of machine-building industries.
PLO3.08 Know the features of design and use of technological equipment of machining processes and equipment

Student workload

The total volume of the course is 180 hours (6 ECTS credits): lectures - 48 hours, laboratory classes - 16 hours, practical training - 32 hours, self-study - 84 hours.

Course prerequisites

To successfully complete the course, you must have knowledge and practical skills in the following disciplines: "Interchangeability, Standardization and Technical Measurements", "Theoretical Mechanics", 'Machine Parts', 'Theory of Machines and Mechanisms', 'Technological Fundamentals of Mechanical Engineering'.

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

Lectures are interactive and use multimedia technologies. Practical classes use a project-based approach to learning, focusing on independent solving of individual tasks, the use of video materials on the principles of technological equipment operation, and methods of machining parts in mechanical engineering. Teaching materials are available to students through the teacher's corporate disk,.

Program of the course

Topics of the lectures

Topic1. THE CONCEPT OF TECHNOLOGICAL TOOLING. PURPOSE AND CLASSIFICATION.

Purpose of technological tooling. Classification of technological tooling. Universal devices (UD). Specialized devices. Universal assembly devices (UAD). Special devices. Hierarchical classification of devices.

Topic 2. METHODS OF FIXTURES DESIGNING

General principles of device design. General structure of the layout of the machine tool device. General sequence of device design. Determination of the type of fixture. Designing a workpiece base scheme. Design of the workpiece fixing scheme. Design of auxiliary and additional technological elements. Execution of a draft design of the device. Calculation of device accuracy parameters. Calculation of the strength of device elements.

Topic 3. DEVELOPMENT OF THE WORKPIECE BASING SCHEME

Methods of basing the workpiece. The concept of the base surface. Types of bases. Schemes for basing the workpiece.

Topic 4. ELEMENTS OF MACHINE TOOLS

Setting elements of devices. Clamping elements of devices. Device housings.

Topic 5. DRIVES OF CLAMPING DEVICES

Pneumatic drive. Hydraulic drive. Pneumohydraulic drives.

Mechanohydraulic drives. Electro-hydraulic actuators. Vacuum drives. Electromechanical drives. Electromagnetic and magnetic drives. Centrifugal and inertial drives. Drives using the kinematics of machine tools.

Topic 6. CALCULATION OF WORKPIECE FIXING FORCES IN THE DEVICE

Forces exerted on the workpiece. Methods for determining clamping forces. Safety factor.

Topic 7. ERRORS OF WORKPIECE LOCATION IN DEVICES

Location error. Error of basing. Clamping error. Device error.

Topic 8. TECHNICAL AND ECONOMIC EFFICIENCY OF THE APPLICATION OF TECHNOLOGICAL TOOLING.

Topic 9. TYPICAL CONSTRUCTIONS OF MACHINERY DEVICES

Chucks. Centers. Mandrels. Vices. Devices for surface grinding machines. Electromagnetic and magnetic devices. Vacuum devices. Devices for broaching machines. Devices for gear processing. Special devices.

Topic 10. TOOLING AND TECHNOLOGICAL EQUIPMENT

General information. Auxiliary devices for axial tooling. Auxiliary tools for turning. Chucks and special devices for broaching tools. Devices for fixing cutters. Devices for boring tools.

Topic 11. ADDITIONAL ELEMENTS OF TECHNOLOGICAL EQUIPMENT

Elements that increase the rigidity of the workpiece. Devices for coordinating and guiding tools. Elements for expanding the technological capabilities of the equipment. Multi-spindle nozzles. Rotary and dividing devices. Angle heads for milling machines

Topic 12: DEVICES FOR CNC MACHINES AND SPECIAL MACHINES

Features of technological equipment for CNC machines. Features of clamping devices for CNC machines. Features of devices for fixing tools on CNC machines. Basic modules (mandrels) of the tooling system. Auxiliary tool systems for CNC machines. Examples of auxiliary tool designs. Devices for aggregate machines and automatic lines.

Topic 13. CONTROL AND MEASURING DEVICES

Basic schemes and elements of control devices. Transmission mechanisms. Typical schemes of control devices for measuring surface deviations. Examples of the use of control and measuring devices. Calculation of the accuracy of control and measuring devices. Coordinate measuring machines.

Topic 14. ASSEMBLY DEVICES

General information. Classification of assembly devices. Basing of parts in assembly devices. Nodes and elements of assembly devices. Features of the design of unified elements. Determination of clamping forces of parts during assembly. Calculation of assembly accuracy in the device.

Topic 15: TRENDS OF FOREIGN MANUFACTURERS OF TECHNOLOGICAL EQUIPMENT

New conceptual solutions in the field of basing and fixing workpieces. Devices for high-speed machining. Trends in the production of tooling that expands the technological capabilities of machine tools. High-speed tool heads. Development of tooling systems for CNC machines. Systems for tool setup. Machining with large overhang tools. Prospects for the development of control and measurement systems.

Topics of the workshops

Topic 1: Analysis of the workpiece and development of the clamping device layout.

Topic 2. Development of a schematic diagram of the workpiece base and selection of the device's setting elements. Design of auxiliary and additional technological elements.

Topic 3. Designing a schematic diagram of the workpiece clamping. Selection of the type of power drive.

Topic 4. Calculation of parameters of the cutting process and power characteristics of the machining process on the technological operation.

Topic 5. Calculation of workpiece clamping forces using a wedge-plunger mechanism.
 Topic 6. Calculation of workpiece clamping forces using a lever system.
 Topic 7. Calculation of workpiece clamping forces using a direct action mechanism.
 Topic 8. Calculation of the force at the output of the clamping drive of the device. Selection of the drive.
 Topic 9. Calculation of the error of basing the workpiece in the device.
 Topic 10. Calculation of device error and analysis of machining accuracy.
 Topic 11. Calculation of the strength of device elements.
 Topic 12. Feasibility study of the clamping device.
 Topic 13. Design of the schematic diagram of the assembly device.
 Topic 14. Designing a schematic diagram of a control and measuring device.
 Topic 15. Development of a schematic diagram of the workpiece base and selection of a set of elements of the control and measuring device.
 Topic 16. Selection of unified technological equipment for performing a separate technological operation on a CNC machine

Topics of the laboratory classes

Topic 1. Study of the design and principle of operation of the three-jaw chuck
 Topic 2. Study of the design and principle of operation of collet chucks.
 Topic 3. Study of the design and principle of operation of the driver chuck.
 Topic 4. Study of the design and principle of operation of the clamping vice. 4.
 Topic 5. Study of the design and principle of operation of universal-division head
 Topic 6. Study of the design and principle of operation of chucks for drills, countersinks and reamers

Self-study

The course involves mastering theoretical knowledge by practicing various calculations, as well as completing an individual assignment for a course project on the calculation and design of a fixture for a specific technological operation. All calculation results are documented in an explanatory note and drawings. Students are also recommended additional materials (videos, web resources) for independent study and analysis.

Course materials and recommended reading

References

1. K. Venkataraman. (2015). Design of Jigs, Fixtures and Press Tools. John Wiley & Sons, Ltd
2. Edward G. Hoffman (2012). Jig and Fixture Design. 5th ed.
3. P.H. Yoshi. (2003). Jigs and Fixtures. Design manual.
4. V. Ivanov , A. Evtuhov , I. Dehtiarov , J. Trojanowska. (2005). Fundamentals of Manufacturing Engineering Using Digital Visualization. Springer Cham
5. Carr Lane Manufacturing Co. (2016). Jigs and Fixtures Handbook. 3rd ed.
6. <https://forkardtharding.de/>
7. <https://www.industrystock.com/en/>
8. <https://www.swisschuck.com/en/>
9. <https://tdgcompany.com/en/>
10. <https://www.roehm.biz/en/>
11. <https://schunk.com/de/en>

Assessment and grading

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

100 points of the final grade consist of assessment results in the form of a credit (30 points) and the ongoing assessment (70 points).

Ongoing assessment:

1. Activity in the class (participation in discussions, answers to the teacher's questions) - 6 points.

2. Current control (2 tests of 10 points each) - 20 points.

3. Completion of tasks in practical classes - 24 points.

4. Completion of an individual task - 20 points.

Credit: oral answer to 3 questions.

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 PERMYAKOV

Date, signature

Guarantor of the educational
program
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