MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

National Aerospace University named after N.Y.Ghukovsky
"Kharkiv Aviation Institute"

Department «Technology of manufacturing of aviation engines»
(№ 204)

APPROVED
Guarantor of the
Tducational Program
_____ M. Orlovskyi
"30" 08 2021 року

WORK PROGRAM SELECTIVE ACADEMIC DISCIPLINE

"Manufacturing and Maintenance of aircraft engines"
(name of the discipline)

Field of education: 27 «Transport»
(code and name of the field of education)

Specialty: 272 «Aircraft transport»
(code and name of the specialty)

Educational program: «Maintenance and repair of aircrafts and aircraft engines»
(name of the educational program)

Form of study: full-time

Higher educational level: first (bachelor)

Kharkiv 2021

Work program selective academic discipline "Manufacturing and Maintenance of aircraft engines"
(name of the discipline)

for students in the specialty 272 « Aircraft transport »
for educational program « Maintenance and repair of aircrafts and aircraft engines »

« 02 » 07 2021, - 11 p.

Developer: Bagmet M.N., PhD, Ass. Prof., Ass. Prof. of the Department № 204
(surname and initials, position, academic degree and academic title) (signature)

Developed and approved by the Department № 204 -
« Technologies of manufacturing of aviation engines »
(назва кафедри)

Minutes dated on «02» July 2021, № 10

Head of the Department Professor, Doctor of sciences
(academic degree and academic title)

(signature)

A.I. Dolmatov
(initials and surname)

1. Course Description

<table>
<tr><td>Names of characteristics</td><td>Field of education, specialty, educational program, higher educational level</td><td>Discipline features (Full-time education)</td></tr>
<tr><td>Amount of credits – 4</td><td>Field of education
27 «Transport»
(code and name of the field of education)</td><td>Training cycle

selective</td></tr>
<tr><td>Modules – 2</td><td rowspan="5">Specialty
272 «Aircraft transport»
(code and name)

Educational program
«Maintenance and repair of aircrafts and aircraft engines»
(name)</td><td>Year:</td></tr>
<tr><td>Thematic modules – 3</td><td>2019/2020</td></tr>
<tr><td>Individual task
Controlwork
(topic)</td><td>Term</td></tr>
<tr><td>Total number of academic hours – 120
For full-time tuition – 48/120</td><td>6</td></tr>
<tr><td>Lectures*</td></tr>
<tr><td rowspan="11">Week number of academic hours for full-time tuition:
classroom – 3,0
student independent work – 4,5</td><td rowspan="11">Higher educational level:
first (bachelor)</td><td>32 hours</td></tr>
<tr><td>Practices, seminars,</td></tr>
<tr><td>-</td></tr>
<tr><td>Laboratory works*</td></tr>
<tr><td>16 hours</td></tr>
<tr><td>Independent work*</td></tr>
<tr><td>72 hours</td></tr>
<tr><td>Individual task</td></tr>
<tr><td>-</td></tr>
<tr><td>Check method:
Modular control, Examination</td></tr>
</table>

Relationship between classes' hours and student independent works' hours is equal: 48/72.
Classroom load can be reduced or increased by one hour, regardless of class schedule.

2. The objectives and the object of the study

Purpose of the study: to form knowledge and skills that allow to scientifically solve problems in the manufacturing, repair and restoration of aviation equipment using the achievements of science in the field of technology and manufacturing.

Task: to have an idea of theoretical foundations of manufacturing and repair of aircraft engines; modeling of technological and manufacturing processes of restoration and repair of aviation equipment; peculiarities of repair of aviation equipment in modern economic conditions; system of computer-aided design of processes of repair of aviation equipment.

Acquired competencies

According to the requirements of the educational-professional program, students must achieve the following competencies:

General competencies (GC):

GC 03. Skills in the use of information and communication technologies
GC 04. Ability to conduct research at the appropriate level
GC 05. Ability to develop and manage projects
GC 07. Ability to work autonomously
GC 08. Ability to work in a team
GC 09. Ability to abstract thinking, analysis and synthesis

Professional competencies of the specialty (SC):

SC 03. Ability to carry out experimental research and measurement of parameters and characteristics of air transport facilities, their units, systems and elements
SC 04. Ability to develop and implement technological processes, technological equipment and technological equipment, means of automation and mechanization at production, operation, repair and maintenance of air transport facilities, their systems and elements
SC 05. Ability to develop and implement technological processes in production, operation, repair and maintenance of air transport facilities, their systems, draw up appropriate documentation, instructions, rules and methods
SC 07. Ability to analyze technological processes of production and repair of objects air transport
SC 17. Ability to maintain technical documentation and reporting on the established forms.

Program learning results:

PLR 03 Apply modern information technologies, technical literature, databases,other resources and modern software tools for solving specialized complex problems air transport
PLR 08 Apply international and national standards and practices in professional activities.
PLR 13 Know the basic technological operations, technological equipment, technological equipment, means of automation and mechanization used in operation, repair and maintenance of air transport facilities, their systems and elements
PLR 14 Develop and implement in production documentation on technological processes of construction, operation, repair and maintenance of aviation facilities transport, their systems and other guidelines, rules and techniques
PLR 16 Perform calculation of basic characteristics and technological parameters processes of production and repair of air transport facilities
PLR 20 Develop design and technological documentation with creation, operation, repair and maintenance of air transport facilities, their systems and elements using specialized modern software
PLR 26 Analyze technical documentation and reporting according to the established forms.

Interdisciplinary Relations: Physics, Aerospace and Rocket Engineering, Theoretical Mechanics, Materials Science, Engineering and Computer Graphics, Interchangeability and Standardization, Mechanics and Machines Theory, Materials and Structures Mechanics

3. Program of discipline

The module № 1. Physical and chemical fundamentals of metallurgical processes

Thematic module 1. Basic machining processes.

Topic 1. Machining processes, their essence and area of application.

The basic concepts and definitions which characterize geometry of a cutting edge, a relative positioning of workpiece and tool, elements of technical normalization (a surface which is processed, the processed surface; the main corners of edge). Movement of workpiece and the tool at cutting, feed, depth of cutting, machine and floor-to-floor time.

The physical phenomena which arise during cutting. Deformation and destruction of metal at cutting. Process of creation of a chip, its types and shrinkage. The thermal phenomena in cutting zone. Influence on heat buildup of various cutting parameters.

Topic 2. The physical phenomena in a cutting zone.

The physical phenomena in a contact zone of tool and material which is processed (friction in a contact zone, creation of an outgrowth, the phenomenon of growth of durability, wear and wear-resistance of cutting tool). Greasing and cooling during cutting. A roughness of the processed surface. Tool materials. Carbonaceous, alloyed steel, steel for high-speed processing. Cemented-carbide compositions, sintered materials, over hard composite materials.

Topic 3. Lathe work.

Parts and elements of a turning tool. Surfaces and coordinate planes during cutting by turning tool. Geometrical elements of a cutting part of a tool. Elements of a cutting mode during processing time. Cutting forces during processing time. Influence of various factors (material of detail, cutting parts of a tool, wear-resistance of the cutting tool, feed, depth of cutting, geometrical elements of a cutting part of tool). A choice of cutting speed.

Planing. The basic concepts about process of planing. Planing and grooving tools, cutting forces during planing, machine time at planing.

Topic 4. Hole-making operations.

Drilling. The basic concepts. A spiral drill, its design and geometry, types of a drill. Forces at drilling. A choice of feed during drilling. Cutting speed during drilling. Sharpening of a drill.

Core drilling. The basic concepts, constructive elements of a vertical drill, force of cutting and torque during core drilling. Elements of a cutting mode during core drilling.

Topic 5. Reaming, milling and broaching processes.

Reaming. The basic concepts. Constructive elements and the basic types of reamers. Modes of cutting during reaming. Milling. The basic concepts. Elements of cutting part of a mill. Types of mills and their designs. Elements of a cutting mode during milling. Cutting forces at milling. A choice of cutting modes at milling. Broaching. Elements of a mode of cutting during broaching time. The basic often and geometrical parameters circular broach. Cutting forces during broaching time. Wear, wear-resistance and speed during broaching time.

Topic 6. Gear cutting and threading.

Methods of cogwheels cutting. Gear cutting tool. Modes of cutting at gear-cutting. Gear shaping. Gear shaving. Thread machining. The common data about grooves. Methods of tapping by cutting tools, combs, taps. Thread-cutting heads, thread milling. Thread grinding.

Topic 7. Abrasive and physical processing.

Abrasive tools and their characteristics. Kinds of grinding wheels. A frame methods of abrasive processing. Electroerosive, electrochemical, ultrasonic, electrobeam and laser processing of constructional materials, their importance and area of application.

Topic 8. Machine tools.

Classification of machine tools. Classification of movements on machine tools. Kinematic circuits of machine tools, their analysis and adjustment. Ways of selection of replaceable cogwheels and conditions of gearing. Step drives of machine tools. Electric regulation of speed of movement. A

hydraulic drive. Typical mechanisms of drives of machine tools. Lathes. Engine lathe (copy devices). Other machine tools of turning group. Features of design and kinematics, technological opportunities. Drilling and boring machine tools. Vertical-, radial - boring machines. Horizontal - boring machine tools. Features of a design and kinematics, technological opportunities. Milling machine tools, their variety, principles of work. The common data about numerical control of machine tools.

Thematic module 2. Cutting tools.

Topic 9. Terms and definitions relating to tools.

Tool contour. Terms and definitions relaying to single-point tools. Carbide inserts. Relative edge strength.

Topic 10. Tool materials.

Ranges of properties for various groups of tool materials. The essential properties. Tool materials.

Topic 11. Tool wear.

Types of tool wear. Tool wear as a function of cutting time. Tool life criteria in production.

The module № 2. The coatings techniques.

Thematic module 3. Technologies for protection and restoration of surfaces.

Topic 12. Introduction in coatings techniques.

Types of coatings. The factors which are taken into account at a choice of a coating. Functional purposes and materials of coatings.

Topic 13. Thermal spray process.

Principles of thermal spraying. Nature of thermal spray coatings The process flow diagram. thermal spray coating bonding mechanisms, factors effecting bonding and subsequent build up of the coating.

Topic 14. Processes of combustion and arc spraying

Combustion spraying. Combustion wire thermal spray process (Metal spraying). The process. Common materials sprayed. Process advantages & disadvantages. Combustion Powder Thermal Spray Process (Flame Spray Process). Arc wire process description. Main applications. General coating characteristics. Process advantages & disadvantages.

Topic 15. High velocity oxy fuel (HVOF).

High Velocity Oxy Fuel (HVOF). Process description. Main applications. General coating characteristics. Available coatings.

Topic 16. Plasma, detonation and cold spraying processes.

Plasma Spraying. Atmospheric Plasma Spraying - APS. Vacuum Plasma Spraying - VPS. The processes. Common materials sprayed. General coating characteristics. Main applications. The Vacuum Plasma Spray Forming (VPSF). Process description. Main applications. Common materials sprayed. Processes advantages & disadvantages. The Detonation Thermal Spraying Process. Process description. The benefits of detonation coatings. General coating characteristics. Typical applications. Cold spray coating process. Process description. Cold spray process advantages & disadvantages. Possible uses for cold spray coatings. Vapor Deposition. Physical vapor deposition (PVD). Vacuum evaporation. sputtering. Ion plating. Process description. Main applications. General coating characteristics. Chemical vapor deposition.

Topic 17. Ion Implantation. Diffusion Coating. Electrochemical Plating.

The processes. Common materials sprayed. Processes advantages & disadvantages. General coating characteristics. Main applications. The common data about electrolysis. Technical characteristics of electrolits, the structure of galvanic coatigs, disseminating ability of electrolits. Requirements concerning quality of surfaces before coating. Preparation of surfaces before coating.

Technological processes of galvanic coating: copper, zinc, cadmium, nickel, lame, lead, tin, silver, gold, their feature, properties, area of application.

4. Course arrangement

Topics	Number of hours				
	Total	including			
		lec.	pr.	lab.	idp.
1	2	3	4	5	6
Module 1. *Physical and chemical fundamentals of machining processes*					
Thematic module 1. Basic machining processes					
Topic 1. Machining processes, their essence and area of application.	8	1	-	-	7
Topic 2. The physical phenomena in a cutting zone.	4	1	-	-	3
Topic 3. Lathe work.	9	2	-	4	3
Topic 4. Holemaking operations.	5	2	-	-	3
Topic 5. Reaming, milling and broaching processes.	5	2	-	-	3
Topic 6. Gear cutting and threading.	9	2	-	4	3
Topic 7. Abrasive and physical processing.	5	2	-	-	3
Topic 8. Machine tools.	5	2	-	-	3
Total thematic module 1	**50**	**14**	**-**	**8**	**28**
Thematic module 2. Cutting tools					
Topic 9. Terms and definitions relating to tools.	5	2	-	-	3
Topic 10. Tool materials.	13	2	-	4	7
Topic 11. Tool wear.	5	2	-	-	3
Total thematic module 2	**23**	**6**	**-**	**4**	**13**
Module 2. Technologies for protection and restoration of surfaces					
Thematic module 3. Technologies for protection and restoration of surfaces					
Topic 12. Introduction in coatings techniques.	5	2		-	3
Topic 13. Thermal spray process.	6	2		-	4
Topic 14. Processes of combustion and arc spraying.	9	2		4	3
Topic 15. High velocity oxy fuel (HVOF).	5	2		-	3
Topic 16. Plasma, detonation and cold spraying processes.	5	2		-	3
Topic 17. Ion implantation. Diffusion coating. Electrochemical plating.	5	2		-	3
Total thematic module 3	**35**	**12**	**-**	**4**	**19**
Individual task	**12**	**-**	**-**	**-**	**12**
Total	**120**	**32**	**-**	**16**	**72**

5. Workshops

№	Theme	Hours
1		
2		
	Total	

6. Practices

№	Theme	Hours
1		
2		
	Total	

7. Laboratory works

№	Theme	Hours
1	Technological parameters, basic equipment and cutting tools for turning operations	4
2	Technological parameters, basic equipment and cutting tools for hole-making operations	4
3	Technological parameters, basic equipment and cutting tools for milling operations	4
4	Investigation of the kinematic accuracy of a gear machined on a gear milling machine.	4
	Total	**16**

8. Independent work

№	Theme	Hours
1	**2**	**3**
1	Topic 1. Castings methods. Sand-mold and shell-mold casting. Casting in metal molds. Centrifugal casting. Pressure die casting.	7
2	Topic 1. Mechanical working. Rolling. Forging. The extrusion process.	
3	Topic 2. Current technologies and equipment for coatings deposition. Types of coatings. The factors, which are taken into account at a choice of a coating. Functional purposes and materials of coatings.	3
4	Topic 3. Processes of combustion and arc spraying. Principles of thermal spraying. Nature of thermal spray coatings. The process flow diagram, thermal spray coating bonding mechanisms, factors effecting bonding and subsequent build up of the coating. Combustion spraying. Combustion wire thermal spray process (Metal spraying). Combustion Powder Thermal Spray Process (Flame Spray Process). High Velocity Oxy Fuel (HVOF). Arc wire process description. Main applications. General coating characteristics. Process advantages & disadvantages.	3
5	Topic 4. Plasma, detonation and cold spraying processes. Plasma Spraying. Atmospheric Plasma Spraying – APS. Vacuum Plasma Spraying – VPS. The processes. Common materials sprayed. General coating characteristics. Main applications. The Vacuum Plasma Spray Forming (VPSF). Process description. Main applications. Common materials sprayed. Processes advantages & disadvantages. The Detonation Thermal Spraying Process. Process description. General coating characteristics. Typical applications. Cold spray coating process. Process description. Cold spray process advantages & disadvantages. Possible uses for cold spray coatings. Vapor Deposition. Physical vapor deposition (PVD). Chemical vapor deposition.	3

1	2	3
6	Topic 5. Ion Implantation. Diffusion Coating. Electrochemical Plating. The processes. Common materials sprayed. Processes advantages & disadvantages. General coating characteristics. Preparation of surfaces before coating. Technological processes of galvanic coating: copper, zinc, cadmium, nickel, lame, lead, tin, silver, gold, their feature, properties, area of application.	3
7	Topic 6. Features of the technology of manufacturing of aircraft engines.	3
8	Topic 7. Machine classification and numbering.	3
9	Topic 8. Thermal treatment used in the manufacture of aircraft engines.	3
10	Topic 9. Workpiece materials.	3
11	Topic 10. The concept of surface quality and its main characteristics.	7
12	Topic 10. The influence of surface quality on the operation properties of the part.	
13	Topic 11. Production and technological processes.	3
14	Topic 12. Types of engineering production.	3
15	Topic 13. Lathe work. Cutting forces during processing time. Influence of various factors (material of detail, cutting parts of a tool, wear-resistance of the cutting tool, feed, depth of cutting, geometrical elements of a cutting part of tool). A choice of cutting speed.	4
16	Topic 14. Gear cutting and threading. Thread machining. The common data about grooves. Methods of tapping by cutting tools, combs, taps. Thread-cutting heads, thread milling. Thread grinding.	3
17	Topic 15. Abrasive and physical processing. Abrasive tools and their characteristics. Kinds of grinding wheels. Frame methods of abrasive processing. Electroerosive, electrochemical, ultrasonic, electrobeam and laser processing of constructional materials, their area of application.	3
18	Topic 16. Machine tools. Step drives of machine tools. Electric regulation of speed of movement. A hydraulic drive. Typical mechanisms of drives of machine tools.	3
19	Topic 17. Types of technical control.	3
20	Homeproject performance	12
	Total	**72**

9. Individual work

Homeproject performance on an individual variant.

10. Teaching methods

Lectures, laboratory works, homeproject and individual consultations.

11. Check methods

Monitoring, paper modules, marks for laboratory works, mark for a homeproject, examination.

12. Criteria for evaluation and distribution of points that students receive

12.1. Distribution of points received by students (quantitative evaluation criteria)

Components of educational work	Points per lesson (task)	Number of sessions (tasks)	Total points
Module 1			
Content module 1			
Work on lectures	0...1	7	0...7
Execution and passing of laboratory works	3...5	2	6...10
Content module 2			
Work on lectures	0...1	3	0...3
Execution and passing of laboratory works	3...5	1	3...5
Modular control	24…30	1	24…30
Module 2			
Content module 3			
Work on lectures	0...1	6	0...6
Execution and passing of laboratory works	3...5	1	3...5
Execution and passing of homeproject	14…20	1	14…20
Modular control	10…14	1	10…14
Total for the semester			**60…100**

The semester control (examination, credit) is carried out in case of refusal of the student from the points of the current test and if there is admission to the exam / credit. During the semester exam / credit the student has the opportunity to get a maximum of 100 points.

The exam/credit card consists of two theoretical questions, the maximum score for each question is 50 (the sum is 100 points).

12.2. Qualitative evaluation criteria

The required amount of knowledge to obtain a positive assessment: as a result of studying the discipline, the student must:

know:

- essence and the basic features and characteristics of materials processing and manufacturing of parts by cutting, casting and also galvanic coating, hardening by deformation and other methods;
- the basic concepts and definitions which characterize geometry of a cutting edge;
- the physical phenomena which arise during cutting;
- cool and lubricate liquids which use during cutting;
- essence of turning, drilling, planning, milling, gear cutting, broaching processes etc., selection of cutting conditions;
- methods of abrasive processing of materials and physical and chemical methods of dimensional processing (electroerosive, electrochemical, ultrasonic);
- the common data about machine tools; classification of machine tools, their kinematic circuits, the analysis and adjustment;
- foundry alloys, their classification, interaction with gases, fire-resistant materials;
- features of castings;
- technological bases of foundry manufacture;

- pattern equipment, mold materials, casting methods, elements of molds;
- technological processes of manufacturing of parts by casting in sand molds, shell molds, metal molds, by centrifugal, vacuum casting, casting under pressure, precision-investment casting;
- materials of patterns, molds;
- areas of application of casting methods, their advantages and disadvantages;
- existing ways of metals hardening, their essence and areas of application;
- features of the basic methods of details protection from corrosion and structure of technological processes of galvanic and powder coating and sequence of their designing;
- basic methods of mechanical working (rolling, forging, extrusion);
- schemes and equipment of the basic methods of mechanical working, die materials and lubrication, defects in rolled plates and sheet, forgings.

The required amount of knowledge to obtain a positive assessment: as a result of studying the discipline, the student

should be able:

- to choose effective ways of processing of materials, their hardening, galvanic coverings of surfaces with the purpose of restoration, protection against corrosion, maintenance of antifriction properties, increase wear resistance, etc.;
- to choose ways of manufacturing of parts depending on conditions of manufacture and a design of a detail;
- to design technological processes of manufacturing castings and parts from powder materials;
- to design according to standards and recommendations equipment and devices for technological processes of manufacturing of parts by different ways, to select the tool, the equipment, and to carry out calculations for adjustment of kinematics of machine tools.

The required amount of knowledge to obtain a positive assessment: as a result of studying the discipline, the student

should have skills:

- designing of technological processes, manufacturing of parts by different ways, selection of tools, the equipment, and performance of calculations for adjustment of kinematics of machine tools.
- The required amount of knowledge to obtain a positive assessment: as a result of studying the discipline, the student

should have a clear idea of:

- improvement existing and new modern technological processes of materials processing, and green technologies.

12.3. Criteria for evaluating student work during the semester

Satisfactory (60-74). Show a minimum of knowledge and skills. Protect all individual tasks, complete and pass all labjratory works, complete a control work and take tests. To know the design, technical conditions, materials of basic parts of aviation engines, technological processes of manufacturing of basic parts of aviation engines.

Good (75-89). Firmly know the minimum of knowledge, complete all tasks, pass the test. Demonstrate the ability to perform and defend all laboratory works within the time limit set by the teacher, with a rationale for the solutions and activities proposed in the work. To know operations of mechanical processing of parts of aviation engines and to be able to design them using modern technologies.

Excellent (90-100). Pass all checkpoints rated "excellent". Full knowledge of basic and additional material. Know all topics. Navigate your textbooks and teacher's aids. It is thorough to know all the technologies used in the manufacturing of aircraft engine parts. Undoubtedly carry out and protect all laboratory works within the terms stipulated by the teacher, justifying the decisions and measures suggested in the works. Have skills in the organization of technological preparation of manufacturing of aircraft engine parts.

Grading Scale: Point and Traditional

Sum of points	Score on the traditional scale	
	Exam, differentiated credit	credit
90 – 100	Excellent	counted
75-89	Good	
60-74	Satisfactory	
0-59	Unsatisfactory	Not credited

13. Literature

Basic literature:

1. Kalpakjian S. Manufacturing Engineering & Technology / Serope Kalpakjian, Steven Schmid. - Instock, 2014. - 1224 pp.
2. Ammen C.W. Metalcasting / C.W. Ammen. - McGraw-Hill, 2000. – 432 pp.
3. Campbell J. Castings: 2nd ed. / J.Campbell. - Butterworth-Heinemann, 2003. – 337 pp.
4. Burakowski T. Surface Engineering of Metals: Principles, Equipment, Technologies / T. Burakowski, T. Wierschon. - CRC Press, 1998. – 608 pp.
5. Handbook of surface treatments and coatings / coordinated by Cartier M.; translated from the French by Curtis J.M., English translation ed. by Polak T.A., Wilcox G.D. - London: Professional Engineering Publishing, 2003. - 412 pp.
6. Boothroyd G. Fundamentals of Machining and Machine Tools: 3rd ed./ G. Boothroyd, WA Knight. - CRC Press, 2006. – 581 pp.
7. Walsh A.R. Machining and Metalworking Handbook / Ronald A. Walsh, Denis R. Cormier. - McGraw-Hill Professional, 2006. - 976 pp.
8. Shaw M.C. Metal Cutting Principles / M.C. Shaw. - Oxford, 2005. – 672 pp.
9. Smith G.T. Cutting Tool Technology: Industrial Handbook / G.T. Smith. - London: Springer-Verlag, 2008. - 605 p.
10. Bilokon B.S. Calculations of cutting conditions for turning, drilling and milling operations. Teacher's aid / B.S. Bilokon, M.K. Knyazyev. – Kharkiv: M. Ye. Zhukovsky National Aerospace University "Kharkiv Aviation Institute", 2009. – 83 p.
11. Knyazyev M.K. Planning of Manufacturing Metal-Cutting Processes. Calculations of Operation Dimensions: Manual to Term Projects / M.K. Knyazyev, M.E. Markovych, B.S. Bilokon. - Kharkiv: M. Ye. Zhukovsky National Aerospace University "Kharkiv Aviation Institute", 2016/ - 144 p.

Additional literature:

1. David J Gingery Publishing. http://www.lindsaybks.com/dgjp/
2. Lindsay Publications. http://www.lindsaybks.com/
3. Stephenson D.A. Metal Cutting: Theory and Practice: 2nd ed. / D.A. Stephenson, J.S. Agapiou - CRC Press, 2005. – 864 pp.
4. Trent E.M. Metal Cutting: 4th Edition / E.M. Trent, P.K. Wright. – Boston: Butterworth-Heinemann, 2000. – 464 pp.
5. Davim J.P. (ed.) Machining: Fundamentals and Recent Advances / J.P. Davim (ed.). - London: Springer, 2008, - 361 pp.

14. Information

http://k204.khai.edu/ru/site/spetsialnost.htm