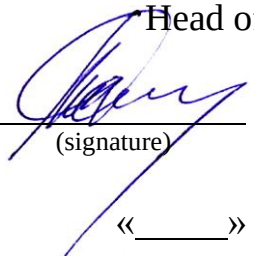
MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aerospace University
"Kharkov Aviation Institute"

Aircraft engine design department (№ 203)

APPROVED
Head of project team



_____ *Oleksandr Bilohub*
(signature) (first and last name)

«_____» _____ 2020

SYLLABUS OF AN ACADEMIC DISCIPLINE

DESIGN AND STRENGTH OF AIRCRAFT ENGINES AND POWER PLANTS

(name of academic discipline)

Field of education *13 «Mechanical Engineering»*
(code and name of a field of education)

Field of study *134 «Aviation and Spacecraft Technologies»*
(code and name of field of study)

Educational program *Aircraft engines and power plants*
(code and name of educational program)

Form of training *Day studies*

Level of higher education *First (bachelor)*

Kharkiv 2020

Working program *Design and strength of aircraft engines and power plants*
(name of academic discipline)
for students of a field of study *134 «Aviation and Spacecraft Technologies»*
educational program *Aircraft engines and power plants*

« *1* » June 20*20* *p.*

Person, who developed the syllabus *DSc, Prof. Sergiy Yepifanov*
(author, job, academic degree and rank) (signature)

Working program was approved at the meeting of the department
Aircraft Engine Design
(department)

Minutes № 1 dated « 28 » August 2020

Head of department *Dr. Sc., Professor* *Sergiy Yepifanov*
(academic degree and rank) (signature) (first and last name)

1. Description of the discipline

<table>
<tr><td>Characteristics</td><td>Branch of science, specialization, academic degree</td><td>Description of the discipline (full-time tuition)</td></tr>
<tr><td>Credits – 6,5</td><td>Field of education:
13 «Mechanical Engineering»
(cipher and name)</td><td>Variable</td></tr>
<tr><td>Modules – 3</td><td rowspan="5">Field of study:

134
«Aviation and spacecraft technologies»
(cipher and name)</td><td>Academic year:</td></tr>
<tr><td>Semantic modules – 3</td><td>2020 / 2021</td></tr>
<tr><td>Individual task
Calculation-graphic work: «Load acting engine rotor. Unloading of radial-thrust bearing»
(title)</td><td>Semester</td></tr>
<tr><td>Total number of academic hours – 96*/195</td><td>6-th</td></tr>
<tr><td rowspan="9">Number of academic hours for full-time tuition:

auditorium – 6

independent work – 6,2</td><td>Lectures *</td></tr>
<tr><td>48 a.h.</td></tr>
<tr><td rowspan="7">Educational program:
Operational diagnostics, maintenance and repair of aircraft engines and PP

Higher education:
First (Bachelor)</td><td>Practices, seminars *</td></tr>
<tr><td>24 a.h.</td></tr>
<tr><td>Laboratory activities *</td></tr>
<tr><td>24 a.h.</td></tr>
<tr><td>Independent work</td></tr>
<tr><td>99 a.h.</td></tr>
<tr><td>Form of examination</td></tr>
<tr><td>exam</td></tr>
</table>

The ratio of hours of classes to independent work is: for full-time education - 96 / 99.

* *Auditory load can be reduced or increased by one hour, depending on the schedule of classes.*

2. Goals and purposes of discipline

Goal: initial images forming about arrangement and strength of aircraft turbine engines, knowledge acquisition about the turbine engine components and parts composition and design.

Task: studying of the engine main components and structural units composition, design, operation conditions and loads, strength analysis.

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

General competencies: *Ability to communicate in the state language both orally and in writing. Ability to communicate in the foreign language. Skills to carry out safe activities, the desire to preserve the environment. Skills in the use of information and communication technologies. Ability to work both independently and in a team with representatives of other professional groups. Ability to make informed decisions in normal and special situations and implement them correctly. Ability to learn and master modern knowledge. Ability to preserve and multiply moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society, and place in the development of society, engineering and technology; ability to use different types and forms of physical activity to relax and lead a healthy lifestyle. Knowledge and understanding of the subject area and understanding of the features of the specialty. Ability to think abstractly, concretely and generalized, to analyze and synthesize*

Special (professional) competencies: *Ability to use the propositions of hydraulics, aero- and gas dynamics to describe the interaction of bodies with gaseous and hydraulic environment. Ability to assign optimal materials for structural elements of aerospace engineering. Ability to carry out the strength analysis of elements of aerospace engineering. Ability to design and test elements of aerospace engineering, its equipment, systems and subsystems. Skills in the use of information and communication technologies and specially configured software in studding and professional activities. Possession of the basics of operation and maintenance of aircraft, engines and their systems. Ability to develop measures to diagnose and eliminate malfunctions and failures of engine systems, analyze the causes of their occurrence, develop and implement measures to prevent them.*

Program learning outcomes: *Fluently communicate orally and in writing in state and foreign languages on professional matters. To have the means of modern information and communication technologies to the extent sufficient for studding and professional activities. To explain their decisions and the basis for their adoption to specialists and non-specialists in a clear and unambiguous form. To have the skills of self-study and autonomous work to refreshing professional skills and solve problems in a new or unfamiliar environment. To have the logic and methodology of scientific knowledge, based on an understanding of the current state and methodology of the subject area. To adhere to the requirements of industry regulations on procedures for the design, manufacture, testing and (or) certification of elements and objects of aerospace engineering at all stages of their life cycle. To explain the influence of design parameters of elements of aerospace engineering on its flight performance. Have an idea of the methods of ensuring the stability and controllability of aerospace engineering. To have the skills to determine loads on structural elements of aerospace engineering at all stages of its life cycle. To understand the principles of mechanics of liquid and gas, in particular, hydraulics, aerodynamics (gas dynamics). To describe the structure of metals and non-metals and know the methods of modifying their properties. To assign optimal materials for elements and systems of aerospace and rocket enginiring, taking into account their structure, physical, mechanical, chemical and operational properties, as well as economic factors. To understand features of workflow in hydraulic, pneumatic, electrical and electronic systems used in aerospace engineering. To apply modern methods of design, construction and production of elements and systems of aerospace engineering in professional activities. To calculate the stress-strain state, determine stability margins of structural elements and the reliability of aerospace engineering. To understand and justify the sequence of design, manufacturing, testing and (or) certification of elements and systems of aerospace engineering. To understand and justify design features and basic aspects of workflow in systems and elements of aerospace engineering. To understand how operational factors*

affect the design of aircraft, engines and their systems. To have a basic knowledge on organization of maintenance and repair of aircraft.

Interdisciplinary links: Engineering Materials Science, Aviation Materials Science, Machine Parts and Construction Basics, Mechanics of Materials and Structures, Technology of Structural Materials, General Arrangement of Aviation Engines and Power Plants.

3. Course content

Module 1

TOPIC 1. Subject and tasks of the course. Its place in educational plan. Bibliography.

TOPIC 2. Main units and power systems of GTE. Operational conditions and loads acting main units and components. Gas forces and moments acting engine units. Methods of decreasing axial forces acting engine rotor. Inertial forces acting engine units. Static and dynamic balancing of rotors. Power systems of rotors and stators. Shafting, construction of coupling junctions. Sources of thermal stresses in engine units and components.

TOPIC 3. Compressor rotors and stators. Loads acting compressor rotor. Clearances between rotor and stator. Sealing of compressor gas path. Methods to provide stable operation of compressor. Constructive materials of axial compressors. Centrifugal compressors, their advantages and disadvantages. Classification of centrifugal compressors. Construction of centrifugal compressors elements. Constructive materials of centrifugal compressors.

TOPIC 4. Functions, operational conditions and requirements to turbines. Classification of gas turbines. Parameters which characterize turbine perfection. Turbine rotor blades, methods of their fixing to disc. Turbine discs, their junction between themselves and with shaft. Determination of axial force acting turbine rotor. Stators of gas turbines. Nozzle boxes, operational conditions, power schemes and fixing to casing. Casings of gas turbines. Cooling of turbine components. Temperature of blades and discs determination. Clearances between rotor and stator. Constructive materials for turbine components manufacturing.

Module 2

TOPIC 5. Strength analysis of rotor blades.

Strength analysis of blade acted by centrifugal forces. Strength analysis of blade acted by gas forces. Total stresses, safety factor.

Rotor blade unloading from bending moments of gas forces by moments of centrifugal forces. Unloading factor.

Specifics of strength analysis of blades with shrouds and non-uniformly heated blades.

TOPIC 6. Strength analysis of rotor blade fixing unit.

Construction and strength analysis of rotor blades fixing units, including dovetail, fir-tree and hinged locks.

TOPIC 7. Loads acting compressor rotor. Strength analysis of drum-type rotor and tie bolt. Strength analysis of junction between disc and shaft of centrifugal compressor. Loads acting turbine shaft. Strength analysis of turbine shaft and flange junction.

TOPIC 8. Strength analysis of discs.

Task of disc strength analysis. Design scheme and design conditions. Main equations of strength condition determination. Methods of numerical solution of these equations.

Features of stresses calculation in discs with step variation of width and discs of centrifugal compressors. Disc safety factor determination by equivalent stresses and failure rotation speed.

Analysis of thermal-stress state of disc by example of constant width disc.

TOPIC 9. Strength analysis of shells. Stator impenetrability analysis. Loads acting shells (casings of compressors, turbines, combustion chambers, thin-wall shafts). Equations of thermal-stress state of shells of rotation. Strength of engine mounting units at rotor blade breaking.

Module 3

TOPIC 10. Clearances between rotor and stator. Contact and expendable seals. Air leakage through labyrinth seal determination.

TOPIC 11. Main and afterburning combustion chambers. Classification, operational conditions, requirements to construction, determination of main geometric parameters. Constructive schemes of main combustors. Construction of main elements of combustion chambers. Cooling of components, thermal stresses decreasing. Constructive materials of combustion chamber components. Function and construction of afterburners. Constructive materials of afterburners.

TOPIC 12. Exhaust systems and thrust reversers.

Exhaust systems of GTE, functions, operational conditions and requirements. Exhaust tubes. Types of jet nozzles. Fixed and variable nozzles. Forces acting elements of jet nozzle. Thermal isolation and cooling of jet nozzles. Thrust reversers and thrust deviators. Power plant as a source of noise and vibration. Constructive methods of noise suppression. Engine infrared radiation problem and methods of its solution.

TOPIC 13. Radial clearance control. Influence of radial clearances on engine performances: thrust, power, specific fuel consumption, acceleration time. Influence of operational conditions on radial clearances of compressor and turbine. Estimation of radial deformation of rotors and stators at steady-state and transient modes. Passive and active radial clearance control. Construction of radial clearance control systems.

TOPIC 14. Engine ecological performances.

Composition of harmful substances creating in GTE, their influence on human health. Mechanisms of harmful substances creation. Methods of emissions suppression: water injection, catalyzers, constructive means, specifics of their using in engines of on-ground and air application. Emission norming and measuring. Engine noise, its main sources, methods of decreasing, norming and suppression.

4. Course arrangement

Names of Modules and Topics	Number of hours				
	full-time tuition				
	total	namely			
		lec	pr	lab	i.w.
1	2	3	4	5	6
Module 1 **Semantic module 1**					
TOPIC 1. Subject and tasks of the course. Its place in educational plan. Bibliography.	5	1	-	-	4
TOPIC 2. Main units and power systems of GTE. Operation conditions and loads acting main units and components.	14	2	2	2	8
TOPIC 3. Compressor rotors and stators. Loads acting compressor rotor. Clearances between rotor and stator.	20	6	2	4	8
TOPIC 4. Functions, operation conditions and requirements to turbines. Classification of gas turbines.	20	6	2	4	8
Modular testing	1	1	-	-	-
Totally for module 1	**60**	**16**	**6**	**10**	**28**
Module 2 **Semantic module 2**					
TOPIC 5. Strength analysis of rotor blades. Strength analysis of blade acted by centrifugal forces.	15	4	4	2	5
TOPIC 6. Strength analysis of rotor blade fixing unit. Construction and strength analysis of rotor blades fixing units, including dovetail, fir-tree and hinged locks.	13	2	2	2	7
TOPIC 7. Loads acting compressor rotor. Strength analysis of drum-type rotor and tie bolt.	15	4	6	-	5
TOPIC 8. Strength analysis of discs. Task of disc strength analysis. Design scheme and design conditions. Main equations of strength condition determination. Methods of numerical solution of these equations.	13	4	4	-	5

TOPIC 9. Strength analysis of shells. Stator impenetrability analysis. Loads acting shells (casings of compressors, turbines, combustion chambers, thin-wall shafts). Equations of thermal-stress state of shells of rotation. Strength of engine mounting units at rotor blade breaking.	11	2	2	2	5
Modular testing	1	1			
Totally for module 2	**68**	**17**	**18**	**6**	**27**
Module 3 **Semantic module 3**					
TOPIC 10. Clearances between rotor and stator. Contact and expendable seals. Air leakage through labyrinth seal determination.	8	2	-	2	4
TOPIC 11. Main combustion chambers. Classification, operational conditions, requirements to construction, determination of main geometric parameters.	14	4	-	4	6
TOPIC 12. Afterburners. Exhaust systems of GTE, functions, operational conditions and requirements. Thrust reversers.	11	3	-	2	6
TOPIC 13. Radial clearance control. Passive and active radial clearance control. Construction of radial clearance control systems.	7	3	-	-	4
TOPIC 14. Engine ecological performances	10	2	-	-	8
Modular testing	1	1			
Totally for module 3	**51**	**15**	**-**	**8**	**28**
IRT					
Individual task **Calculation-graphic work on the topic of:** *«Load acting engine rotor. Unloading of radial-thrust bearing»*	**16**	**-**	**-**	**-**	**16**
Totally for course	**195**	**48**	**24**	**24**	**99**

5. Laboratory works

№	Name	Hours
1	Main units and power systems of GTE	2
2	Construction of axial and centrifugal compressors	4
3	Construction of gas turbines	4
4	Compressor and turbine rotor blades strength analysis	2
5	Construction and strength analysis of rotor blade fixing units	2
6	Strength analysis of shells	2
7	Contact and expendable seals. Leakage through seal determination	2
8	Construction of main combustion chambers	4
9	Construction of afterburners and exhaust systems	2
	Total	**24**

6. Practical works

№	Name	Hours
10	General arrangement of turbine engine	2
11	Loads acting compressor rotor	2
12	Turbine cooling	2
13	Compressor and turbine rotor blades strength analysis	4
14	Strength analysis of rotor blade fixing units	2
15	Distribution of forces and moments acting engine rotor. Axial force calculation which acts elements of compressor and turbine	2
16	Rotor unloading	2
17	Strength analysis of shaft	2

18	Strength analysis of compressor and turbine discs	4
19	Strength analysis of shells	2
	Total	**24**

7. Independent work

№	Name	Hours
1	Bibliography survey	4
2	Power systems, shaftings and main loads acting engine units and components	8
3	Compressors of aircraft engines and power plants	8
4	Gas turbines of aircraft engines and power plants	8
5	Strength analysis of rotor blades	5
6	Strength analysis of rotor blade fixing unit	7
7	Strength analysis of drum-type rotor and tie bolt. Strength analysis of shaft and flange junction	5
8	Strength analysis of discs. Thermal-stress state determination	5
9	Analysis of shells strength and stability	5
10	Contact and expendable seals. Air leakage through labyrinth seal determination	4
11	Main combustion chambers	6
12	Afterburners, exhaust systems and thrust reversals	6
13	Radial clearance control	4
14	Engine ecological performances	8
15	Calculation-graphical work	16
	Total	**99**

8. Individual task

1. Calculation-graphical work «*Load acting engine rotor. Unloading of radial-thrust bearing*».
Stages of work:
- rotor scheme designing and drawing, bearings types and displacement choosing;
- axial force acting compressor rotor determination;
- axial force acting turbine rotor determination;
- load acting radial-thrust bearing determination;
- means to decrease axial force acting radial-thrust bearing analysis;
- explanatory report drawing-up;
- defense of work.

9. Learning methods

Basic forms of learning:
- lectures;
- laboratory works;
- individual task;
- independent work.

Lecture gives to student basic conceptions, bases of theory, relations which necessary to prepare for laboratory works and individual task.

Lecture solves one didactic problem only – gives primary knowledge about subject of topic, formulates main problems.

Laboratory works are based on verbal (analytic) description of the object (engine, unit or component) and its material presentation using special didactic materials (mockups, posters, drawings

etc.). During laboratory works, team-based approach of students work is applied.

Main form of learning is independent work. It cannot be done without preliminary knowledge given in lecture. During independent work, students study lecture material, prepare to laboratory works, make calculation-graphic task.

10. Questions for independent work

Topics on engine structure

Module 1

1. Classification of heat engines. Areas of different engine types application.
2. Functions and main parameters of GTE compressors.
3. Classification of compressors, their comparative qualification. Requirements to compressors.
4. Types of axial compressors rotors, their comparative qualification.
5. Loads acting rotor of axial compressor.
6. Axial force acting compressor rotor determination. Means for decreasing axial force acting radial-thrust bearing of compressor.
7. Construction of drum rotors and disc rotors of compressors.
8. Construction of drum-and-disc rotors of compressors.
9. Rotor blades of axial compressors, main requirements and constructive materials.
10. Compressor rotor blades fixing.
11. Constructive means for compressor gas-dynamic stability improving.
12. Structure of axial compressors stators. Guide vanes fixing.
13. Clearances between compressor rotor and stator. Gas path and oil cavities sealing.
14. Construction and operation of expendable seals. Leakage through labyrinth seal determination.
15. Construction of centrifugal compressor.
16. Functions of GTE turbines, operational conditions. Requirements to turbines.
17. Main parameters of gas turbines.
18. Turbine rotor blades, requirements to them, constructive materials.
19. Turbine rotor blades fixing.
20. Turbine discs junction between themselves and with a shaft.
21. Calculation of axial force acting turbine rotor.
22. Construction of gas turbines stators. Nozzle boxes fixing.
23. Clearances between compressor rotor and stator. Sealing of gas path.
24. Radial clearance control in compressors and turbines.
25. Turbine rotor blades and nozzle boxes cooling.
26. Discs of gas turbines cooling.

Module 3

27. Principles of combustion. Functions, operational conditions and operational process of main combustion chambers. Constructive materials.
28. Classification of main combustion chambers. Requirements to combustion chambers.
29. Elements of main combustion chambers.
30. Functions, operational principles and operational conditions of afterburners. Requirements to them. Constructive materials.
31. Construction of afterburner.
32. Functions of exhaust systems. Operational conditions and requirements to exhaust systems. Constructive materials.
33. Construction of exhaust systems of turboprop and turboshaft engines. Functions and construction of flow mixers used in turbofan engines.
34. Construction of subsonic fixed and variable nozzles.

35. Construction of supersonic fixed and variable nozzles.
36. Functions and construction of thrust reversers and thrust deviators.
37. Noise of turbine engine. Means of noise suppression.
38. Composition of engine harmful emissions.
39. Methods of CO and NOx emissions suppression.
40. Engine noise, its sources and suppression.

Topics on engine strength
Module 2

1. Main loads acting engine units. Axial gas forces acting engine units.
2. Main loads acting engine units. Inertia forces acting engine units. Static and dynamic balancing of rotors.
3. Main loads acting engine units. Gyroscopic moment.
4. Clearances between rotor and stator of compressor. Sealing of gas path and oil cavities.
5. Construction and operation of expandable seals. Air leakage through labyrinth seal determination.
6. Strength analysis of flange junction between disc of centrifugal compressor and shaft.
7. Strength analysis of central tie bolt of compressor rotor.
8. Loads acting rotor blades of compressor and turbine. Goals of blade strength analysis and main suppositions.
9. Design modes for blade strength analysis. System of coordinates and rule of signs.
10. Blade tensile stresses from centrifugal forces determination.
11. Blade torsion by centrifugal forces.
12. Blade bending by gas forces.
13. Blade bending by centrifugal forces.
14. Compensation of blade bending from gas forces, by moment of centrifugal forces. Compensation factor.
15. Total stresses in cross-sections of blade body. Strength analysis of blade body.
16. Factors which cause thermal stresses in blades. Specifics of strength analysis of naturally twisted blades and blades with shroud.
17. Loads acting disc of compressor or turbine. Main suppositions taken at disc static strength analysis. Contour load applied to disc rim determining.
18. First equation of disc stress state derivation, taking into account condition of element' equilibrium.
19. Second equation of disc stress state derivation, taking into account strain compatibility condition.
20. Stresses calculation in non-uniformly heated disc of arbitrary profile by method of finite differences.
21. Stress condition analysis of solid rotated uniformly-heated disc without contour load.
22. Stress condition analysis of disc at different load and different geometry.
23. Stress condition analysis of disc which has off-center holes.
24. Specifics of disc with step variation of width and of disc with blades on side surface analysis.
25. Equivalent stresses in disc. Disc strength estimation by equivalent stresses and failure rotation speed.
26. Specifics of strength analysis of non-uniformly heated blades.
27. Specifics of static strength analysis of non-uniformly heated disc.
28. Strength analysis of dovetail lock of rotor blade.
29. Strength analysis of fir-tree lock of rotor blade.
30. Strength analysis of hinged lock of rotor blade.
31. Strength analysis of drum-type rotor.

32. Construction and strength analysis of drum-and-disc-type rotor.

33. Loads acting elements of combustion chamber. Strength analysis of external casing of combustion chamber.

34. Loads acting elements of combustion chamber. Analysis of internal casing stability.

35. Construction and strength analysis of flange junctions of main combustion chambers and afterburners.

36. Construction and strength analysis of engine shafts.

11. Testing

The course is divided into three modules:

1. Power systems, compressors and turbines of engines.
2. Main and afterburning combustion chambers, exhaust systems.
3. Clearance control and emissions.

Module 1 is passed during 8-th week (one attempt), module 2 is passed during 12-th week (one attempt), module 3 – 16-th week (one attempt).
Before passing modulus, student must make all laboratory works, individual task and independent work of this modulus.

Execution of laboratory works – in writing form, defense – orally.

Term of the home task defense – *10-th* week. Delay of defense on one week – 2 points minus; 2 weeks – 4 points minus.

Semester 6 – examination.

12. Evaluation criteria and distribution of the points that the students get

12.1 Distribution of the points that the students get (quantitative evaluation criteria)

Components of educational work	Points for one lesson (task)	Number of lessons (tasks)	Total number of points
Module 1			
Work at lectures	0…0.5	7	0…3.5
Execution and defense of laboratory (practical) works	1…2	6	6…12
Modular testing	12…20	1	12…20
Module 2			
Work at lectures	0…0.5	7	0…3.5
Execution and defense of laboratory (practical) works	1…2	5	5…10
Modular testing	12…20	1	14…20
Module 3			
Work at lectures	0…0,5	6	0…3
Execution and defense of laboratory (practical) works	1…2	3	3…6
Modular testing	9…15	1	10…15
Execution and defense of individual task	4…7	1	4…7
Total for semester			**60…100**

Semester testing (examination) is held in case the student gives up points of modular testing and is permitted to the examination. The permission is given if the student has finished and passed all laboratory and practical works and also successfully defended the home task.

Maximum total score of the examination is 100 points.

The examination card is composed of three theoretical questions and one practical task. The theoretical questions are distributed as follows:

–the first question is on compressor and turbine design (Module 1);

–the second question is on combustion chamber, afterburner and exhaust system design (Module 3);

–the third question is on the engine main parts strength analysis.

The practical task concerns elements of the engine parts strength analysis.

Maximum number of points for each question is 25.

12.2 Qualitive evaluation criteria

To get positive mark, the student must

know:

– purpose of main engine components (compressor, combustion chamber, turbine, exhaust system) and requirements to them;
– advantages and disadvantages of axial and centrifugal compressors;
– loads that act rotor of axial compressor and methods of compressor rotor unloading;
– structure of compressor rotor;
– structure of compressor stator;
– structure of compressor and turbine rotor blades;
– methods of turbine discs and shaft junction;
– methods of turbine blades and discs cooling;
– types of main combustion chamber;
– elements of main combustion chamber;
– purpose and main elements of afterburners;
– types of exhaust systems;
– order of compressor and turbine rotor blade strength analysis;
– main loads that are taken into account at the rotor blade strength analysis;
– order of compressor and turbine disc strength analysis;
– main loads that are taken into account at the disc strength analysis;
– main loads that act casings of combustion chamber and order of their strength and stability analysis;

know how:

– join compressor or turbine rotor blade to a disc;
– join disks between themselves;
– join a disk to a shaft;
– identify type of compressor by direction of flow, by number of stages, by shape of the gas path;
– cool a nozzle vane, a rotor blade and a disc;
– change area of jet nozzle;
– provide thrust reversing;
– evaluate the rotor blade strength;
– evaluate the disc strength.

12.2 Criteria of the student evaluation during semester

Satisfactory (60-74). The student must have the required minimum of knowledge. He must finish and pass all laboratory and practical works, defend the individual task, pass modular testing with positive mark. He must know purpose and structure of compressor, turbine, combustion chamber, exhaust system. He must identify number of stages and methods of compressor stability improvement, explain main loads that act rotor blade and what stresses do they initiate, name main parts of a disc and explain its shape.

Good (75-89). The student must be proficient in minimum knowledge. He must finish and pass all laboratory and practical works, defend the individual task with good mark, pass modular testing with positive mark. Know main trends in turbine engine development, confidently identify type of compressor,

turbine, combustion chamber and exhaust system, type of the rotor blade attachment to a disc, methods of main combustion chamber and afterburner ignition. He must explain principles and methods of rotor unloading and identify unloading cavities using drawings; name main stresses that originate in rotor blades and disks and explain their distribution by radius; explain main loads that act casings of combustion chamber and methods of their analysis.

Excellent (90-100). He must finish and pass all laboratory and practical works, defend the individual task with good or excellent mark, pass modular testing with excellent mark (one or two modules with "good" mark and minimum 80 points are permitted). Know main and additional material in full scale. Explain influence of temperature and compressor pressure ratio growth on the engine specific mass and specific fuel consumption. Know influence of the bypass ratio on the engine perfection. Successfully identify type of compressor, turbine, combustion chamber, name their parts and methods of their junction using a drawing or mockup, explain main loads and how are they transmitted between parts, between modules and engine components and finally to the aircraft. Explain the problem of compressor stability and methods of this problem solution. Know methods of turbine nozzle vanes, rotor blades, discs and casings cooling, reasons of thermal stress origination. Name loads that act rotor blades, discs and casings at different operation conditions; explain which conditions are selected for strength analysis and why; draw diagrams of stress distribution by radius for blades and discs. Explain principles of blades unloading from bending. Know basic materials which the main engine parts are made from.

Grade scales: national and ECTS

Grade scale	National scale	
	For exam, course project (work), practice	For test
90-100	"excellent"	Passed
75-89	"good"	
60-74	"satisfactory"	
0-59	"non-satisfactory"	Not passed t

13. Methodological support

1. Didactic materials (manuals, Power point presentations, posters etc.).
2. Mockups of TJEs, TFEs, TPEs, TShEs in 103, 124 rooms and hall of Motor building.
3. Tutorials for different topics of the course.

14. Recommended literature for the course

Main

1. Yepifanov, S. Major units of aircraft gas turbine engines: Tutorial [Text] / S. Yepifanov, Y.Shoshin, Y. Gusev. – Kharkov.: National Aerospace University "Kharkov Aviation Institute", 2013. – 101 p.

2. Yepifanov, S. Afterburners and exhaust systems of turbine engines: Tutorial [Text] / S. Yepifanov, Y.Shoshin, V. Chygryn. Kharkov.: National Aerospace University "Kharkov Aviation Institute", 2014. – 32 p.

3. The Jet engine [Text] // The Technical Publications Department of RR plc .– Derby, England . – 1996. – 278 p.

4. Treager, I.E. Aircraft gas turbine engine technology [Text] / I.E. Treager. – 3-rd ed. – Glencoe/McGraw-Hill. 2001. – 677 p.

5. Hunecke, K. Jet engines. Fundamentals of theory, design and operation [Text] // K. Hunecke. – 6-th impression/ - Osceola.: Motorbooks IP&W, 2003. – 241 p.

6. Boyce, M.P. Gas turbine engineering handbook [Text] / M.P. Boyce. - 3-rd ed. – Gulf Professional Publishing. – 2006. – 936 p.

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