MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aerospace University
«Kharkiv Aviation Institute»

APPROVED
Head of the admissions committee
of National Aerospace University
«Kharkiv Aviation Institute»

_____ Oleksii LITVINOV
«27» March 2024 y.

ENTRANCE TEST PROGRAM

to obtain a master's degree

by the educational and professional program in the specialty

134 «Aerospace Engineering»

(education program *«Aircraft Engines and Power Plants»*)

in 2024

Kharkiv
2024

INTRODUCTION

Entrance test for obtaining a master's degree in an educational and professional program in a specialty

134 «Aerospace Engineering»
(code and name of field of study)

(educational program *«Aircraft Engines and Power Plants»*)
(name of Educational program)

Based on levels HPK6, HPK7, the test takes place in accordance with the "Rules of admission to study in National Aerospace University «Kharkiv Aviation Institute» in 2024 year» in the form of an individual written professional exam or a computer test, which is accepted by the professional examination commission for a certain specialty (educational program), the composition of which is approved by order of the rector of the University.

The professional exam includes questions by topic:
− «Aviation Material Science»,
− «Machine Parts and Bases of Designing»,
− «Working Process and Design of Aircraft Engines and Power Plants»,
− «Dynamics and Strength of Aircraft Engines and Power Plants»,
− «Manufacturing Technology of Aircraft Engines and Power Plants».

The list of questions by topic is given in the program.

Knowledge evaluation criteria

1. The result of the professional exam is determined on a scale from 100 to 200 points.

2. The entrance test is performed in the form of a test. The result of the professional exam is calculated according to the formula:

$$80+k*n,$$

where   **k** is the number of points for a correct answer to a question (is equal to **5)**,
   n – the number of correct answers (is equal to **24**).

3. If the entrant received less than 100 points, it is considered that he failed the exam and is not allowed to participate in the competition.

1.   Question by topic   « Aviation Material Science »
(name)

1.   Definition and classification of metals. General properties of metals and alloys, methods of their determination.
2.   Methods of determining the hardness of metals and alloys.
3.   Cold and hot plastic deformation of metals, their definitions and possibilities.
4.   Characterization of metal recovery and recrystallization processes. Critical degree of plastic deformation.
5.   Classification and marking of carbon steels. The influence of alloying elements on the

mechanical properties of steels. Classification and marking of alloy steels, tool steels and alloys.

6. Composition, properties, marking of corrosion-resistant, heat-resistant and heat-resistant steels, iron-nickel alloys and nickel-based alloys.

7. Main types of heat treatment of carbon and alloy steels, their characteristics.

8. Hardening of steels. Methods of hardening, their characteristics, execution technology.

9. Tempering of steels, its types. Structure, properties and application of steels after various types of tempering.

10. Chemical and thermal treatment of steels and alloys. Purpose, characteristics of modes of implementation of various types of chemical and thermal processing.

11. Classification of aluminum alloys. Deformable aluminum alloys that are not strengthened by heat treatment, their composition, properties, marking and application.

12. Heat treatment of aluminum alloys. Deformable aluminum alloys strengthened by heat treatment. Their composition, labeling, properties and application.

13. Classification of titanium alloys according to the structure in the equilibrium state. Properties and applications of alloys with different structures. Marking of titanium alloys.

14. Titanium alloys strengthened by heat treatment. Types of thermal treatment, structure, properties and application of thermally strengthened titanium alloys.

15. Characteristics of copper, classification of copper-based alloys. Brasses and bronzes, their composition, marking and use.

16. Characteristics of magnesium. Magnesium-based alloys, their composition, heat treatment, labeling and use.

References

1. Інженерне матеріалознавство. Метали, полімери, кераміка, композити: підручник / Я.С. Карпов, В.В. Остапчук, О.Г. Попова, І.М. Тараненко. – Харків: Нац. аерокосм. ун-т ім. М. Є. Жуковського «Харків. авіац. ін-т», 2020. – 384 с.

2. Афтанділянц Є.Г. Матеріалознавство: Підручник / Є.Г. Афтанділянц, О.В. Зазимко, К.Г. Лопатько. – Херсон: Олді-плюс, 2013. – 612 с.

3. Конструкційне матеріалознавство: підруч. для учнів проф.-техн. навч. закл.: гриф МОН України / В.М. Гарнець, В.М. Коваленко. – Київ: Либідь, 2007. – 384 с.

2. Question by topic « Machine Parts and Bases of Designing »
(name)

1. Basic provisions used in calculations and design. Basic concepts, classification of details and nodes. Criteria for the performance of parts.

2. Materials for parts of general and special purpose. Loads in machines. Strength under constant stresses. Strength under alternating stresses.

3. Removable connections. General Information. Purpose of threaded connections. Thread types. Distribution of forces between the turns of the "screw-nut" pair. Types of destruction of elements of threaded connections. Calculation of thread turns.

4. Static strength of threaded connections. Calculation of bolts loaded with axial and transverse forces under the condition of admissibility and inadmissibility of joint opening. Dynamic strength of threaded connections. Basic calculation cases. Means of increasing the strength of threaded connections of aviation and space products.

5. Calculation of groups of bolted connections under different types of loads. Peculiarities of calculation of group threaded connections of aviation and space equipment.

6. Keyed and slotted connections. Types and basics of calculations. Types of centering

and planting.

7. Non-separable connections. Rivet joints. Types and classification. Distribution of forces between rivets. Calculation of single rivets and group riveted joints. Comparative assessment of welded and riveted joints in terms of strength and weight. The use of integral connections in aerospace engineering.

8. Types of welds. Stress concentration in welds and methods of increasing their strength. Calculation of connections loaded with force and moment.

9. Transmission mechanisms, their purpose, classification and drive structure in mechanical engineering and aerospace engineering. Designation and calculation of "screw-nut" gears with sliding and rolling friction. "Screw-nut" transmissions in aircraft control mechanisms and technological equipment.

10. Classification, purpose, fields of use of gears. The nature of the teeth and types of damage. Gear accuracy. Forces that act in the engagement of different types of gears. Design loads on teeth. Materials of gear wheels, thermal and chemical-thermal strengthening of teeth.

11. Shafts and axles. Purpose and nature of work. Design and verification calculations of the strength of shafts and axles. Calculations of shafts for stiffness and oscillations. Materials and construction of shafts and axles. Design and technological measures to increase the durability of shafts and axles. Features of the design of shafts of aviation and space equipment. Flexible shafts.

12. Rolling and sliding bearings. Fields of use. Classification and construction of bearings. Accuracy, kinematics, friction losses. Types of damage. Materials. Selection of bearings according to static and dynamic load capacity. Speed of rolling bearings. Designs of bearing assemblies of aviation and space technology.

13. The main types of mechanical couplings. Purpose and classification of couplings. Deaf, elastic and compensating couplings. Controlled and self-controlled clutches. Safety couplings. Characteristics of couplings and the basis of their calculations. The operation of clutches in aircraft transmissions.

References

1. Деталі машин: підруч. для студентів машинобуд. спец.: гриф МОН України / К.І. Заблонський. – Одеса. – АстроПринт, 1999. – 404 с.

2. Деталі машин і основи конструювання: навч. посіб. / В.М. Доценко, Ю.В. Ковеза. – Харків: Нац. аерокосм. ун-т ім. М. Є. Жуковського «Харків. авіац. ін-т», 2018. – 212 с.

3. Деталі машин: підруч. для студентів вузів: гриф МОН України / Д.М. Коновалюк, Р.М. Ковальчук. – К.: Кондор, 2004. – 584 с.

3. Question by topic « Working Process and Design of Aircraft Engines and Power Plants »

(name)

1. Types and areas of use of aircraft engines.
2. Working process of piston engines. Four-stroke and two-stroke engines. Methods of mixture formation. Methods of ignition. Methods of cooling.
3. Thermodynamic analysis of the cycle of gas turbine engines. Expression of the useful (effective) work of the TJE cycle through the parameters of the work process. The connection of efficient and free operation with the specific thrust of the engine.
4. Dependence of useful work of the cycle, specific thrust and specific fuel con-

sumption on the degree of pressure increase. Optimum and economic degree of pressure increase.

5. Dependencies of specific power and specific fuel consumption of turboshaft and turbojet engines on parameters of the working process.

6. Optimum distribution of the cycle work in turboprop engine between propeller and reaction.

7. Work of cycle of turbofan without flow mixing and its optimal distribution between flows. Purpose, schemes, organization of the work process and characteristics of mixing chambers of turbofan. The influence of the work process parameters on the specific parameters of the turbofan.

8. Working process in the stage of the axial compressor. Velocity triangles. The shape of the interblade passages. The main limitations affecting the operation of the compressor stage. Purpose of inlet guide vanes.

9. Characteristics of multistage compressor.

10. Working process in the stage of the axial gas turbine. Velocity triangles. The shape of the interblade passages. Characteristics of turbine.

11. Working process in combustion chamber. The choice of fuel for aviation GTEs. Excess air/fuel ratio. Combustion temperature. Limits of stable burning and stable ignition. Organization of stable operation of the gas turbine combustion chamber.

12. GTE performances: part-load, altitude, velocity, and climatic.

13. Selection of the maximum and cruising thrust of the aircraft engine.

14. Purpose, working conditions and requirements for compressors. Classification of gas turbine compressors, parameters, comparative assessment. Axial and centrifugal compressors. Design schemes of axial compressors. Requirements for the design of the compressor and ways of their implementation. Types of axial compressor rotors, their comparative evaluation. The construction of the working blades of the compressor and their fastening nodes.

15. Loads acting on the compressor rotor. Stators of compressors. Clearances between the rotor and the stator. Sealing of the flow part of compressors. Means of ensuring pump-free operation of the compressor in all modes of engine operation.

16. Centrifugal compressors, their disadvantages and advantages. Classification of centrifugal compressors. Design of elements of centrifugal compressors.

17. Purpose, working conditions and requirements for AD and EU turbines. Classification of gas turbines. Parameters that characterize the perfection of the design of the turbine unit. Working blades of turbines, means of their connection with the disk. Turbine disks, their connection between themselves and with the shaft.

18. Stators of gas turbines. Nozzle devices, working conditions, power schemes and means of attachment to the housings. Casings of gas turbines. Cooling of turbine parts. Determination of the temperature of turbine blades and disks. Clearances between the rotor and the stator. Contact and expendable seals. Calculation of air flow throughout the labyrinth seal.

19. Unloading of the working blade feather from bending moments of gas forces by moments from centrifugal forces. Unloading factor.

20. Classification, working conditions, design requirements, determination of the main geometric dimensions of the main combustion chamber. Design schemes of gas turbine combustion chambers.

21. Design of combustion chamber elements. Cooling of parts, combating dangerous temperature stresses.

22. Purpose and design of afterburner combustion chambers.

23. GTE output devices, purpose, working conditions, requirements for output devices.

Output nozzles. Types of jet nozzles. Adjustable and non-adjustable nozzles. Forces acting on jet nozzle elements. Thermal insulation and cooling of nozzles.

24. Reversible and deviator devices. Power plant as a source of noise and vibration. Constructive methods of noise reduction. The problem of infrared radiation of engines and means for its solution.

References

1. Терещенко, Ю. М. Газотурбінні двигуни літальних апаратів [Текст] / Ю. М. Терещенко, Л. Г. Бойко, О. В. Мамлюк. – К.: Вища школа, 2000. – 319 с.

2. Єпіфанов, С. В. Конструкція авіаційних двигунів: підручник [Текст] / С. В. Єпіфанов. – Нац. аерокосм. ун-т ім. М. Є. Жуковського «Харків. авіац. ін-т», 2022. – 336 с.

3. Гаркуша, О. І. Загальний устрій авіаційних двигунів [Текст] / О. І. Гаркуша. – Нац. аерокосм. ун-т ім. М. Є. Жуковського «Харків. авіац. ін-т», 2022. – 66 с.

4. Д'яченко, В. Г. Теорія двигунів внутрішнього згоряння: підручник [Текст] / В. Г. Дьяченко. – Х. : ХНАДУ, 2009. – 500с.

4. Question by topic «**Dynamics and Strength of Aircraft Engines and Power Plants**»

(name)

1. Main components and power systems of the gas turbine engine. Operating conditions and load on the main components and parts of the engine. Gas forces and moments acting on gas turbine assemblies. Means of reducing the axial forces acting on the engine rotors. Designs of the rotor supports of the gas turbine engine. Inertia forces acting on GTE nodes. Static and dynamic balancing of rotors. Power systems of rotors and stators. GTE transmissions, design of couplings. Sources of temperature stresses in AD and EU components and parts.

2. Calculation of the strength of the drum-type rotor and the tightening bolt. Calculation of the node connecting the centrifugal compressor rotor to the shaft.

3. Calculation of the axial force acting on the turbine rotor.

4. Calculation of the strength of blades from the action of centrifugal forces. Calculation of the strength of blades from the action of gas forces. Total stresses, safety factor.

5. Features of the calculation of blades with bandage shelves, unevenly heated blades.

6. Design and calculation of the strength of compressor and turbine blades fastening nodes.

7. Calculation of the strength of the disks of compressors and turbines, derivation of the main calculation equations of the stress state. Solving the main calculation equations of the disk for strength by the finite difference method.

8. Peculiarities of calculating disks with a jump-like change in thickness and disks of centrifugal compressors. Determination of the safety margin of the disk by equivalent stresses and destructive rotation frequency.

9. Kinematic diagrams of gearboxes. Simple transfers. Reducers for driving one or two screws. Differential and planetary reducers. Locked toothed planetary gears. Selection of the coaxial reducer scheme. Conditions of assembly, coexistence and neighborhood.

10. Oscillations of compressor and turbine blades. Forms of self-oscillations of working blades. Calculation of frequencies of natural oscillations of working blades. Combating dangerous vibrations of compressor blades and turbines in engines.

11. Oscillations of compressor and turbine disks. Forms of self-oscillations of disks. Calculation of frequencies of natural oscillations of discs. Combating dangerous vibrations of compressor discs and turbines in engines.

12. Oscillations of aircraft engine shells. Forms of self-oscillations of shells. Calculation of frequencies of natural oscillations of shells. Combating dangerous vibrations of aircraft engine casings.

13. Critical frequency of rotation of a weightless shaft with one disk. Concept of "rigid" and "flexible" shaft. Factors influencing the critical rotations of rotors. The influence of forces stretching or supporting the shaft. Effect of torque. Gyroscopic moment and its influence on critical revolutions. Determination of critical rotations of rotors taking into account the gyroscopic moment.

14. Determination of natural frequencies of transverse oscillations of shafts carrying a number of discs (multi-disc rotor). Forced oscillations of rotating rotors, their causes. Determination of critical rotor rotation frequencies using a frequency diagram.

15. Design means of combating critical shaft rotation frequencies. Design of rotor support dampers. Features of work. Calculation of elements of damper supports. Peculiarities of operation and design of rotor supports of the gas turbine engine. Design of bearings. Gas and oil seals.

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1. Єпіфанов, С. В. Конструкція авіаційних двигунів: підручник [Текст] / С. В. Єпіфанов. – Нац. аерокосм. ун-т ім. М. Є. Жуковського «Харків. авіац. ін-т», 2022. – 336 с.

2. Чигрин, В. С. Коливання [Текст] : навч. посібник по лаб. практикуму / В. С. Чигрин, А. И. Скрипка. – Х. : ХАІ. – 1999. – 35 с.

3. Шошин, Ю. С. Компресори авіаційних газотурбінних двигунів [Текст] навч. посібник / Ю. С. Шошин. – Х. : ХАІ. – 2002. – 26 с.

4. Шошин, Ю. С. Турбіни авіаційних газотурбінних двигунів [Текст] : навч. посібник / Ю. С. Шошин. – Х. : ХАІ. – 2003. – 37 с.

5. Шошин, Ю. С. Розрахунок на міцність робочих лопаток компресорів і турбін [Текст] : навч. посібник / Ю. С. Шошин, С. В. Єпіфанов, Р. Л. Зеленський. – Х. : ХАІ. – 2006. – 28 с.

6. Шошин, Ю. С. Розрахунок на міцність дисків компресорів і турбін [Текст] : навч. посібник / Ю. С. Шошин, С. В. Єпіфанов, Ф. М. Муравченко. – Х. : ХАІ. – 1998. – 28 с.

7. Полетучий, О. І. Основи конструювання авіаційних редукторів [Текст] : Ч. 1 і 2 / О І. Полетучий, В. М. Ридченко. – Х. : ХАІ. – 1994.

5. Question by topic « Manufacturing Technology of Aircraft Engines and Power Plants »

(name)

1. Errors from elastic deformations of the system.
2. Rigidity of the technological system and production methods of its assessment.
3. Errors due to dimensional wear of the tool, thermal deformations of the vibration system and other factors.
4. The influence of the geometric accuracy of the machine on the accuracy of processing. Calculation of the total processing error.

5. Methods of setting up machines. Charts of processing accuracy. Dot and accuracy charts. Essence, order of construction and conditions of use. Basic statistical characteristics. Practical curve and histogram. The procedure for constructing a theoretical curve. Properties of the normal distribution law.

6. Tasks and necessity of dimensional analysis.

7. Calculation-analytical and regulatory methods of calculating allowances and operational sizes. The order of construction of the dimensional scheme of the technological process.

8. Identification of technological dimensional chains using graphs. Calculations of technological dimensional chains.

9. Structural elements and geometric parameters of the cutter.

10. Kinematics of the cutting process.

11. Classification of materials of cutting tools. International classification of groups of use of materials of cutting tools.

12. Classification, technological possibilities and use of blade and abrasive cutting tools.

13. The design sequence of a unit TP of mechanical processing. Working out the design for manufacturability.

14. The procedure for determining the type of production. Productivity and efficiency of technological processes.

15. Selection of methods of obtaining initial blanks. Selection of technological bases for installation of blanks.

16. Drawing up plans for the treatment of individual surfaces. Building a common processing route. The choice of the place of chemical and thermal treatment of the technological process.
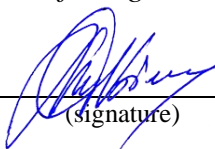
17. Technical control.

References

1. Якімов, О.В. і ін. Технологія машино- та двигунобудування [Текст]: Підручник / Якімов О.В. інш. – Одеса, ОНПУ, 2005. – 720 с.

2. Кукляк, М.Л. Металорізальні інструменти. Проектування [Текст]: навч. посібник / М.Л. Кукляк, І.С. Афтаназів, І.І. Юрчишин. – Львів: Видавництво Національного університету «Львівська політехніка», 2003. – 556 с.

3. Технологічне оснащення [Електронний ресурс] : навч. посіб. до практ. робіт / А. В. Онопченко, М. О. Курін. – Харків : Нац. аерокосм. ун-т ім. М. Є. Жуковського «Харків. авіац. ін-т», 2023. – 72 с.

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5. Сорокін В.Ф., Третяк В.В., Данько К.А. Проектування операцій на верстати с ЧПК. Токарна обробка. 2018. Харків: Нац. аерокосм. ун-т ім. М. Є. Жуковського "Харків. авіац. ін-т": 50 с. УДК: 004.896:621.9.06-529:621.941(076.5)

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Guarantor of the educational program *Aircraft Engines and Power Plants*

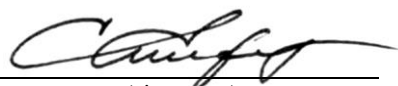| DSc., Professor		Oleksandr Bilohub
(academic degree and rank)	(signature)	(first and last name)

The program was reviewed and agreed upon at a joint meeting of the graduating departments of aircraft engine design and aircraft engine production technologies

Minutes # 2 dated « 29 » February 2024.

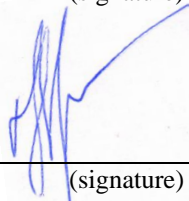| Head of department 203, DSc., Professor		Sergiy Yepifanov
(academic degree and rank)	(signature)	(first and last name)

T.A. Head of department 204, PhD, Associated Professor		Sergiy Nyzhnyk
(academic degree and rank)	(signature)	(first and last name)

The entrance test program for obtaining a master's degree in the educational and professional program in the specialty 134 "Aviation and rocket and space engineering" (educational program Aviation engines and power plants) was agreed by the scientific and methodical commission of the National Aerospace University "Kharkiv Aviation Institute" in the fields of knowledge "Mechanical Engineering", "Electrical Engineering" and "Transport", "Military Sciences, National Security, State Border Security"

Minutes # 6 dated « 1 » March 2024.

Head of EMC 1 PhD, Associated Professor		Sergiy NYZHNYK
(academic degree and rank)	(signature)	(first and last name)