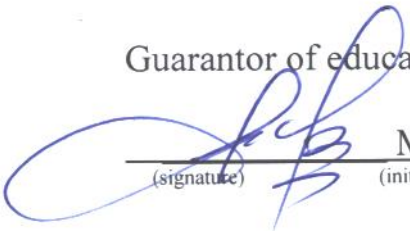
Ukraine Ministry of Science and Education
National Aerospace University of N.E. Zhukovsky
"Kharkov Aviation Institute"

Department of Aircraft and Helicopter Designing

APPROVED

Guarantor of educational program



M. M. Orlovskyi
(signature) (initials and surname)

« 30 » _August_ 2022

WORKING PROGRAM OF THE SELECTIVE EDUCATIONAL DISCIPLINE

« Aircraft Operating and Life Durability»
(the name of the discipline)

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

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

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

Tuition form: full-time

Level of higher education: first (bachelor)

Kharkov 2022

Work program _« Aircraft Operating and Life Durability»_____
(the name of the discipline)
for specialty students __272 «Air transport»_____
educational program _«Maintenance and repair of aircraft and aircraft engines»

«_30_» __08___ 2022, _16 p.

Developer: _Filipkovskij S.V., Professor, D.Sc., Senior Researcher_____
(name, position, degree, scientific degree) (signature)

Program is agreed with graduate department of aircraft and helicopter designing

_____
(the name of the department)
The report No _1__ from « _30_» ___08____ 2022

Head of Department Ph.D., Associated Professor _____ A. M. Humennyi
(degree, scientific degree) (signature) (initials and surname)

1. Description of the discipline

<table>
<tr><td>Indicators</td><td>Field of knowledge, speciality, education program, higher education level</td><td>The discipline characteristics (full-time tuition)</td></tr>
<tr><td>Number of credits – 4,0</td><td rowspan="15">Field of knowledge
27 «Transport»
(code and name of the field of knowledge)

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

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

Level of higher education
first (bachelor)</td><td>Professional training cycle
(optional)</td></tr>
<tr><td>Number of modules – 2</td><td>Academic year:</td></tr>
<tr><td>Number of substantial modules –</td><td>2022/2023</td></tr>
<tr><td>Individual task:
Methods for determining the resource of aircraft structures
(name)</td><td>Semester</td></tr>
<tr><td>Total number of hours – 120
Ratio of auditorium classes number of hours to total number of hours is 48 / 120</td><td>_7_-th</td></tr>
<tr><td rowspan="13">Number of hours per week for full-time tuition:
auditorium – 3
student’s independent work – 6</td><td>Lectures *</td></tr>
<tr><td>32 hours</td></tr>
<tr><td>Practices*</td></tr>
<tr><td>_16_ hours</td></tr>
<tr><td>Laboratory classes *</td></tr>
<tr><td>_–_ hours</td></tr>
<tr><td>Independent work</td></tr>
<tr><td>_72_ hours</td></tr>
<tr><td>Inspection</td></tr>
<tr><td>Module checking,
Exam</td></tr>
</table>

Ratio of auditorium classes number of hours to independent work ones is:
48/ 72

*** Auditorium time can be decreased or increased per an hour depending on timetable.

2. The purpose and objectives of the discipline

The purpose of the study: to form students' scientific base, theoretical and practical knowledge in the field of organization and implementation of processes aimed at maintaining, preserving and restoring the airworthiness of aircraft, including airplanes and helicopters, according to the criterion of resource and fatigue life of their structures.

Task: students gain knowledge: about modern methods of determining the resource of aircraft structures; on the provision and maintenance of fatigue life, survivability and resource in general of aircraft (airplanes and helicopters); acquaintance with the main provisions of the "Air Code of Ukraine", Standards of airworthiness of airplanes and helicopters, certification of aircraft; consolidation of previously acquired knowledge in the following disciplines: basics of aerospace technology; theoretical mechanics; general design of aircraft and aircraft engines, technical operation of aircraft, etc.; activating the motivation to study and prepare the student to choose a place of practical activity in the new market conditions.

Obtained competences:

General competences (GC):

GC 1. Familiarity and understanding the subject field and understanding professional activity.

GC 2. Ability for abstract thinking, analysis and synthesis.

GC 3. Creativity, initiativeness, enterprise and ability to work in team.

GC 4. Ability to estimate and provide quality of performed works.

GC 5. Prognostication of own activity results from the point of view of inadmissibility of ecological situation worsening and hazard appearing for people health.

GC 6. Internal need for purposeful improvement of professional knowledge and skills during studying and professional activity.

Professional competences (PC):

PC 1. Application the mathematical apparatus for solving problems in the field of structure designing and manufacturing.

PC 2. Ability to describe interaction of bodies between each other and also with gas and hydraulic medium on the base of a base knowledge from base sections of physics, mechanics, electrostatics, electrodynamics, optic, aerohydrodynamics.

PC 3. Ability to state and solve problems of parameters designing of products and processes of their manufacturing.

PC 4. Ability to make estimation of loadings applied to structural components on the base of their operation conditions.

PC 5. Ability to calculate components of aviation and rocket-space technics, including ones made of composite materials using knowledge from the mechanics and strength of materials and structures.

PC 9. Ability to apply corresponding software (program languages, program package) to make physical and mathematical calculations in the field of designing and manufacturing of aviation structures.

PC 12. Develop technical and design documentation for aerospace technic main components manufacturing.

Estimated results of studying (RS):

RS 1. Ability of mathematical and logical thinking, knowing main terms, ideas and methods of fundamental mathematics and skills of their application during solving the specific problems.

RS 4. Knowing modern information and communication technologies enough for studying and professional activity.

RS 5. Regulation of loading applied to A/C assemblies using technical task, arrangement schematics, technical and reference literature, computers according to typical calculation procedures.

RS 6. Calculate mode of deformation, determine load-carrying capability of structural components of aviation and rocket-space technics.

RS 8. Calculate strength of units and joints of aerospace technics on the base of schematics and pilot projects using technical and reference literature, CAD/CAE means, according to typical calculation procedures.

RS 14. Development designing documentations, sections of explanatory notes for pilot projects of mean complexity of aerospace product components and making drawings by means of existing methods on the base of normative documents and operating standards, including application of CAD means.

Learning outcomes:

As a result of studying the discipline the student must:

know:

- basic concepts, terms and definitions of the discipline "Resource and durability of aircraft";
- the content of the main processes, concepts and ideas about providing the resource of aircraft structures;
- general requirements to the resource and durability of aircraft structures in the expected operating conditions;
- the main factors of resource conservation and durability of aircraft structures;
- power and other operational factors of the expected operating conditions of the aircraft;
- methods and ways of saving the resource and durability of aircraft structures;
- main characteristics of a typical flight of an aircraft and their brief description;
- features of operation and maintenance of the airframer and functional systems of the aircraft from the standpoint of ensuring the resource and durability of aircraft

structures.

be able:

- diagnose and analyze the process of resource consumption of aircraft structures;
- evaluate the design and technological features of the creation and operation of the aircraft;
- calculate the resource consumption of aircraft structures;
- provide the required levels of aircraft flight safety according to the criterion of the resource of their structures;
- to search and analyze the causes: the emergence of foci of probable destruction due to fatigue of the structural elements of the aircraft; violation of the rules of flight and technical operation of aircraft structures;
- to develop measures to prevent and eliminate the destruction of the structural elements of the aircraft.

have an idea:

- on the international practice of maintaining the airworthiness of aircraft on the criterion of resource and durability of their structures;
- on the organization of resource provision and fatigue life of aircraft structures in operating organizations and aircraft owners.

Interdisciplinary links:
The course is based on the knowledge gained in the study of Physics, Chemistry, Mathematics, Descriptive Geometry and Engineering Graphics, Theoretical Mechanics, Theory of Mechanisms and Machines, Machine Parts, Resistance of Materials, Materials Science, Aerohydrogas Dynamics, Dynamics .

3. The program of the discipline

Module 1

Topic 1. The purpose and objectives of the course

The contribution of domestic scientists and designers in the study and determination of the resource of aircraft, the development of methods to ensure a given durability of aircraft. Achievements of KhAI scientists in ensuring the resource and durability of aircraft. List of recommended reading.

Topic 2. Regulatory documents governing the provision of resource and durability of aircraft

Modern requirements for ensuring the safety of aircraft flights by the criterion of fatigue life of aircraft structures. Air Code of Ukraine. ICAO documents (*P 656, CD-104, PANS-OPS, Doc 9376 и др.*). AR IAC documents (*НЛГС: АП-23, АП-25 и др.; НЛГВ: АП-27, АП-29 и др.; НЛГД: АП-33 и др.; РДК, РТМ; РЦ АП*). *Г*ОСТи (*ГОСТ 27.002-89, ГОСТ В 23743-88, ГОСТ 23207-78, ГОСТ 16504-81*). ОСТи (*ОСТ 1 00209-76, ОСТ 1 00210-76*) etc.

Topic 3. Loads on the power structures of the aircraft

The main power elements of the aircraft structure are airplanes and helicopters. Particularly responsible elements of the design of the aircraft and helicopter. Typical flight of an airplane / helicopter and its components. Load on the structure of the aircraft: types, nature of action and changes in a flight accident, the nature of variable loads on the structure of the aircraft. Criteria for assessing loads on particularly important structural elements: the concept of equal, external and internal forces, stresses and strains.

Topic 4. Characteristics of cyclic loading and fatigue resistance of aircraft structures

Basic concepts and terms: Fatigue. Resistance to fatigue. Fatigue damage. Crack. Destruction from fatigue. Low-cycle and multi-cycle fatigue. Fatigue tests. Main characteristics: Stress cycles. Frequency, period of cycles. Maximum, minimum, amplitude, average stress in cycles. Symmetric, asymmetric, zero-stress cycles. Cycle asymmetry coefficient. Cyclic durability. Fatigue curve of structural materials. Limit stress diagrams and their connection with the "σ - ε" diagram. "Hard" and "soft" load of the aircraft structure.

Topic 5. The equation of fatigue curves of the structural elements of the aircraft

Equations of fatigue curves - empirical dependences of fatigue characteristics. Parameters and coefficients of the fatigue life curve: physical content and definition. Features of application of equations of curves of fatigue of elements of designs of aircraft.

Topic 6. Determination of fatigue life and service life of aircraft design elements

Experimental determination of fatigue resistance characteristics. Samples of aircraft design elements for fatigue studies. The nature of fatigue fractures in samples of structural elements depending on the load scheme and the level of applied stresses. Methods for calculating the durability of structural elements of the aircraft. Estimated assessment of the endurance limit on the characteristics of the mechanical properties of the materials of the structural elements of the aircraft. Calculation of fatigue life and service life of aircraft construction elements.

Topic 7 Characteristics of stress and strain distribution in the cross sections of typical elements of aircraft structures

Methods for determining the distribution of stresses and strains in the characteristic sections of structural elements. Stress concentration. Theoretical and effective stress concentration coefficients. Coefficients: sensitivity to stress concentration; sensitivity to stress cycle asymmetry; the influence of the absolute dimensions of the cross section; the influence of surface roughness; the impact of surface hardening; the influence of deep plastic deformation of the structural material. Influence of

structural and technological factors on the stress-strain state of power elements in the area of the hole for fasteners (bolts, rivets, etc.).

Topic 8. The influence of design, technological and operational factors on the characteristics of fatigue life of structural elements of aircraft

Influence of manufacturing technology (properties, structure, surface condition) of aircraft design elements, structures (dimensions, geometry, stress concentration) and operating conditions (load cycle asymmetry, type of stress state, load mode, load frequency, temperature, environment, fretting corrosion) on the characteristics of resistance to fatigue failure of structural elements of the aircraft.

Modular control

Module 2

Topic 9. Scattering of fatigue resistance characteristics of aircraft structural elements and methods of its evaluation

Probabilistic nature of fatigue resistance characteristics. The main stages of the analysis of the results of statistical tests. Methods of statistical processing of fatigue test results. Regularities of durability scattering, endurance limits, crack resistance characteristics of aircraft design elements.

Topic 10. Resistance to fatigue in the presence of cracks in the structural elements of the aircraft

General provisions of fracture mechanics. Stress intensity coefficients. Formulas for determining the growth rate of cracks. Kinetic diagram of fatigue failure: basic patterns; threshold values of stress intensity coefficients; area of stable crack development; limit state.

Topic 11. Fatigue durability of typical connections of structural elements of aircraft

Influence of the material of the structural elements of the joints. Influence of the design of fasteners (bolts, rivets), the number of their rows, the number of shear planes, the distribution of forces in the rows of fasteners on the fatigue life of joints. Influence of structural and technological factors (radial tension, axial tightening, deformation hardening, coating, interlayers) and operational factors (stress cycle asymmetry, stress cycle frequency, temperature, corrosive environment) on the durability of riveted and bolted joints.

Topic 12. Calculation of fatigue life of typical aircraft connections

Methods for calculating the durability of joints with a given technology of their manufacture. Determination of durability: transverse and longitudinal shear joints; ear connections; filler transitions.

Topic 13. Fatigue durability of aircraft panels and spars

Fatigue durability of wing panels: in the area of cutouts and holes for fuel flow; in the area of transverse joints, longitudinal joints and stringer ends. Ensuring fatigue life of

removable wing panels. Fatigue durability of panel designs in the conditions of fretting corrosion. Features of definition and maintenance of durability: designs of spars and ribs of a wing; longitudinal and transverse joints of belts and walls of spars.

Topic 14. Resource and fatigue life of power elements of the aircraft landing gear

Influence of design-technological and operational factors on the durability of landing gear joints. Determination of fatigue life of power elements of the landing gear (taking into account their wear).

Topic 15. Ensuring the operational survivability of the airframe

Characteristics of survivability of structural elements, components and units of the airframe. Methods of ensuring the operational survivability of the aircraft airframe. Methods of preventing and inhibiting the growth of fatigue cracks. Methods of protection of structural elements from corrosion and corrosion under the action of stresses in structural elements.

Topic 16. Operational manufacturability of the airplane / helicopter

Methods and devices for diagnosing fatigue of aircraft structural elements.
Methods of repair and restoration of bearing capacity of airframe elements.

Modular control

4. Structure of the discipline

Modules and Theme Names	Hours				
	Total				
		Lec	Pra	Lab	Ind
1	2	3	4	5	6
Module 1					
Topic 1 The purpose and objectives of the course	4	2	–	–	2
Topic 2 Regulatory documents governing the provision of resource and durability of aircraft	4	2	–	–	2
Topic 3 Loads on the power structures of the aircraft	4	2	–	–	2
Topic 4 Characteristics of cyclic loading and fatigue resistance of aircraft structures	4	2	–	–	2
Topic 5 The equation of fatigue curves of the structural elements of the aircraft	4	2	–	–	2
Topic 6 Determination of fatigue life and service life of aircraft design elements	9	2	–	4	3
Topic 7 Characteristics of stress and strain distribution in the cross sections	4	2	–	–	2

of typical elements of aircraft structures					
Topic 8 The influence of design, technological and operational factors on the characteristics of fatigue life of structural elements of aircraft	4	2	–	–	2
Modular control			–	–	
Total for Module 1	**37**	**16**	**–**	**4**	**17**
Module 2					
Topic 9 Scattering of fatigue resistance characteristics of aircraft structural elements and methods of its evaluation	4	2	–		2
Topic 10 Resistance to fatigue in the presence of cracks in the structural elements of the aircraft	4	2	–		2
Topic 11 Fatigue durability of typical connections of structural elements of aircraft	4	2	–	–	2
Topic 12 Calculation of fatigue life of typical aircraft connections	12	2	–	6	4
Topic 13 Fatigue durability of aircraft panels and spars	9	2	–	4	3
Topic 14 Resource and fatigue life of power elements of the aircraft landing gear	6	2	–	2	2
Topic 15 Ensuring the operational survivability of the airframe	4	2	–	–	2
Topic 16 Operational manufacturability of the airplane / helicopter	4	2	–	–	2
Modular control			–	–	
Total for Module 2	47	16	–	12	19
Total for Modules 1 та 2	84	**32**	–	**16**	36
Individual Task		–	–	–	
Control measure (exam)	7	–	–	–	–
Total hours	**7**	**32**	**–**	**16**	**36**

5. Seminar Classes Themes

Nos	Theme	Hours
1	Absent	–
	Total	–

6. Practice Themes

Nos	Theme	Hours
1	Absent	–
	Total	–

7. Laboratory Classes Themes

Nos	Theme	Hours
1	Fatigue designing of elements with holes and fittings	2
2	The influence of fretting corrosion on the durability of structural elements made of aluminum alloys	2
3	The effect of radial tightness on the durability of the strip with holes filled with bushings, bolts and rivets	2
4	Fatigue durability of hinge joints	2
5	Influence of the type of rivets and the number of their rows on the durability of the riveted joints	2
6	Influence of design and technological factors on durability of shear bolt connections	2
7	The influence of design parameters on the durability of the longitudinal joints of the webs of the spar	2
8	Influence of cutouts on wing panels durability	2
	Total	16

8. Independent Work

Nos	Theme	Hours
1	Methods and ways to increase the fatigue life of the aircraft	36
	Total	

9. Individual Task

1. Methods for determining the resource of aircraft structures

10. Educational Methods

Verbal (explanation and discussion), visual (illustration and presentation), practical (practical classes).

11. Inspection Methods

Attendance inspection. Individual passing of laboratory works, modules. Exam

12. Estimation Criteria and Rating Distribution

12.1. . Distribution of rating, which students get (numerical estimation criteria)

Education work	Points for a task	Number of tasks	Total number of points
Module 1			
Work on lectures	0…1	8	0…8
Making laboratory class	3...5	4	12...20
Modular control	18…22	1	18…22
Module 2			
Work on lectures	0…1	8	0…8
Making laboratory class	3...5	4	12...20
Modular control	18…22	1	18…22
Total for term			**60…100**

Term checking (test) is performed in case when a student renounces the rating of current tests and when there is allowance to test. When taking the term test, student can get maximum 100 points.

Question card for the test includes three theoretical questions. The first task gives up to 40 points; the second is up to 30 points; the third is up to 30 points (sum — 100 points).

12.2. Qualitative estimation criteria

Knowledge required for getting a positive mark:

- Main terms and definitions of reliability and survivability of AT; quantitative indexes of reliability, safety and survivability of A/C; interrelation of efficiency, reliability, survivability and cost of A/C;
- External reasons of aviation accidents (unfavorable influence of environment);
- Internal reasons of aviation accidents («Human Factor» and failures of AT);
- Distribution laws for discrete and continuous random values, numerical characteristics of distribution, their integral estimations; main calculational methods of AT reliability analyses;
- Main experimental methods for AT reliability and survivability analysis, main processes, which take place under damages of AT and their consequences.

Skills required for getting a positive mark:

- Make quantative analysis of reliability and survivability of airframe and systems of A/C as a whole;
- Calculate system reliability parameters for various functional connections of the system elements.

12.3 Student’s term work estimation criteria

Satisfactory (60–74). Show minimum of knowledge and skills. Make and defend all the laboratory works. Now quatitative criteria for AT reliability estimation.

Good (75–89). Show firm knowledge and skills. Make and defend all the laboratory works in time specified by the professor. know distribution laws for discrete and continuous random values, distribution numerical characteristics, their integral estimations, main calculation methods for AT reliability analysis.

Excellent (90–100). Know main and auxiliary material fluently. Know all themes. Make and defend all the laboratory works in time specified by the professor unmistakably with detailed justification of the solutions and means, which were applied in the assignments. Know distribution laws for discrete and continuous random values, distribution numerical characteristics, their integral estimations. Be able to apply calculation methods for AT reliability analysis

Rating scale: pointed and traditional

Total rating	Score on a traditional scale	
	Exam, test with a grade	Test
90 – 100	Excellent	Passed
75 – 89	Good	
60 – 74	Satisfactory	
01 – 59	Unsatisfactory	Not passed

13. Methodological Provision

Lecture notes and literature, which is in the library, methodical office and in electronic form on the server of the Department of Aircraft and Helicopter Design (listed below in section 14 of this program).

14. Recommended Literature

1. Scientific Grounds of Structural and Production Concepts to Provide Aircraft Life Time [Text]: V. O. Boguslayev, S. A. Bychkov, O. G. Grebenikov, M. I. Moskalenko, A. M. Gumenniy, E. T. Vasilevskiy, A. P. Eretin, O. D. Donets, V. F. Sementsov, V. O. Grebenikov, O. M. Stoliarchuk. – Monography. Nat. Aerospace Univ. «KhAI», 2019. – 266 pages.
2. D. M. Anderson and W. M. Mc Jee. Development and Application of Marker Loads for Fatigue Crack Growth Study on a Full-Seal Test Article. AIAA/ASME/SAE 17 th Structures Structural Dynamics and Materials Conference, 1976, pp. 126 - 132.
3. L. R. Holl, R. C. Shah, W. L. ENGSTROM. Fracture and Fatigue Crack Growth Behaviour of Surface Flaws and Flaws Originating at Fastener Holes. Technical Report AFFDL-TR-74-47, Volume I, May 1974.
4. J. Schijve. The significance of fractography for investigations of fatigue 261 crack growth under variable-amplitude loading. Fatigue and Fracture of Engineering Materials and Structures, v. 22, Number 2, 1999. – p. 87 - 99.

5. SURESH S. Micromechanisms of Fatigue Crack Growth Retardation Following Overloads. Engineering Fracture Mechanics. – 1983.V. 18. –262 p. 577 – 593.
6. E. P. Probst, B. M. Hillberry. Fatigue Crack Delay and Arrest Due to Single Peak Tensile Overloads. A JAA JOURNAL1974, V. 12 №3, pp. 330 – 335.
7. C. Bathias, M. Vancon Mechanisms of Overload Effect an Fatigue Crack Propagation in Aluminium Alloys. Engineering Fracture Mechanics, 1978, №2. – p. 409-423.
8. J .D. Bertel, A. Clerivet, C. Bathias. R Ratio Influence and Overload Effects on Fatigue Crack Mechanisms. «Advanced Fracture Reseach» Conference Proccedings, Cannes, 1986. – p. 943 - 951.
9. J. Schijve. Accumulation of Fatigue Damage in Aircraft Materials and Structures AGARD - CP – 118, 1974.
10. M. Lang and Marci. The influence of single and multiple overloads on fatigue crack propagation. Fatigue and Fracture of Engineering Materials and Structures, v. 22, Number 4, April 1999. – p. 251 - 271.
11. M. M. I. Hammouda, S. S. Ahmad, M. H. Seleem and H. E. M. Sallam. Fatigue crack growth due to two successive single overloads. Fatigue and Fracture of Engineering Materials and Structures, v. 21, Number 12, December 1998. – p. 1537 - 1547.
12. V. W. Trebules Jr. R. Roberts and R. W. Hertzberg (1973). Effect of multiple overloads on fatigue crack propagation in 2024-T3 aluminum alloy. In: ASTM STP 536. – p. 115 - 146.
13. C. Amzallag, J. A. Le Duff, C. Ribin and G. Motter (1994). Crack closure measurements and analysis of fatigue crack propagation under variable amplitude loading. In: ASTM STP 1231. – p. 311 - 333.
14. P.J. Bernard, T.C. Lindley and C.E. Richards (1976). Mechanisms of overload retardation during fatigue crack propagation. In: ASTM STP 595. – p. 78 - 97.
15. R. D. Brown and J. Weertmann (1978). Effects of tensile overloads on crack closure and crack propagation rates in 7050 aluminum. Engng Fracture Mech.10. – p. 867 - 878.
16. D. Damri and J. F. Knott (1976). Fatigue crack growth retardation affer single peak and block overloads in a structural steel. In: Proc. of the 4th Int. Conference on Fatigue and Fatigue Thresholds, 15-20 July. – p. 1505 - 1510.
17. G .Marci (1979). Effects of the active plastic zone on fatigue crack growth rates. In: ASTM STP 677. – p. 168 - 186.
18. H. Doker and V. Bachmann (1988). Determination of crack opening load by use of threshold behavior. In. ASTM STP 1982. – p. 247 - 259.
19. W. T. Matthews, F. I. Baratta and G. W. Driscoll (1971). Experimental observation of a stress intensity history effect upon fatigue crack growth rate.
20. G. Marci (1980). The effects of the plastic wake zone on the conditions for fatigue crack propagation. Int. J. Fracture Mech. 16. – p. 133 - 153.
21. . M. Darvish and S. Johansson (1995). Fatigue crack growth studies under combination of single overload and cyclic condesation environment. Engng Fracture Mech. 52. – p. 295 - 319.
22. E. Welsch, D. Eifeer, B. Scholtes and E. Macherauch (1986). Residual stress distribution caused by overloading in the neighborhood of crack tips and their influence on the propagation of fatigue cracks. In: Residual Stresses in Science and Technology (E. Macherauch and Hauk, eds). DGM, Oberursel. – p. 785 - 792.
23. M. M. I. Hommouda, S. S. E. Ahmad, M. H. Seleem and H. E. M. Sallam. Fatigue crack growth due to two successive single overloads. Fatigue and Fracture of Engineering Materrials and Structures. – 1998. – V. 21. – p. 1537 - 1547.

24. D. M. Shuter and Geary (1996). Some aspects of fatigue crack growth retardadion behaviour following tensile overloads in a structural steel. Fatigue Fract. Engng Mater. Struct. 19(2/3) . – p. 185 - 199.
25. Y. K. Tur and O. Vardar (1996). Periodic tensile overloads in 2024-T3 Al-alloy. Enging Fracture Mech. 53(1). – p. 69 - 77.
26. N. A. Fleck (1985). Fatigue crack growth due to periodic underloads and and overloads. Acta Metall. 33. – p. 1339 - 1354.
27. Y. Lu and K. Li (1993). A new model for fatigue crack growth after a single overload. Enging Fracture Mech 46. – p. 849 - 859.
28. M. M. I. Hommonda, S. S. E. Ahmad, A. S. Sberbini and H. E. M. Sallam Deformation behaviour at the tip of a physically short fatigue crack to a single overload. Fatigue and Fracture of Engineering Materials and Structures. V. 22, Number 2, 1999.
29. TM Hsu and L. M. Lassiter. Effects of Compressive Overloads on Fatigue Crack Growth. Journal of Aircraft, v. 12, Number 2, 1975. – p. 100 - 104.
30. J. D. Bertel, A. Clerivet, C. Bathias. R.Ratio Influence and Overload Effects on Fatigue Crack Mechanisms. «Advanced Fracture Reseach». Conference Proccedings, Cannes, 1981. – p. 943 - 951.
31. Takeshi Kanazawa, Susumu Mahida, Kougu Stoga. On the Effect of Cyclic Stress Ratio on the Fatigue Crack Propagation. Engeneering Fracture Mechanics. – 1975. Vol. 7. – p. 445 - 455.
32. Albertin L., Hudak S. Effect of Compressive Loading on Fatigue Crack Growth Rate and Striation Spacing in Type 2219 - T851 Aluminum Alloy. Fractography and Materials Science, ASTM STP 733 1981. – p. 187 – 201.
33. Marissen R. The Influence of Compression Loads and of dk/da on the Crack Propagation under Variable Amplitude Loading. Engineering Fracture Mechanics. – 1984. V. 5, №5. – p. 863 – 879.
34. M. Land (1998). The influence of compressive loads on fatiguee crack propagation in metals. Fatigue Fract. Engng Mater. Struct. 21. – p. 65-84.
35. M. Land and Huang. The influence of compressive loads on fatigue crack propagation in metals. Fatigue Fract. Engng Mater. Struct. V. 21, Number 1, 1988.
36. R. Pippan (1987). The growth of short cracks under cyclic compressions. Fatigue Fract. Engng Mater. Struct 1. – p. 267 - 270.
37. H. D. Dill and C. R. Saff (1977). Analysis of crack growth following compressive high loads based on crack surface displacements and contact analysis. ASTM STR 673. – p. 141 - 152.
38. . E. Zaikren and R. O. Ritchie (1985). On the role of compression overloads in influencing crack closure and the theshold condition for fatigue crack growth in 7150 aluminum alloy. Engng Fract. Mech.22. – p. 35 - 48.
39. R. L. Corlson and G. A. Kardometeas (1993). Effects of compressive load excursions on fatigue crack growth. Int. J. Fatigue 16. – p. 141 - 146.
40. R. I. Stephens, G. W. Mc Burney and L. J. Oliphant (1974). Fatigue crack growth with negative R-ratio following tensile overloads. Int. J. Fract 10. – p. 587 - 589.
41. W. X. Alzos, A. C. Skat and B. M. Hillberry (1976). Effect of single overloads/underload sycles on fatigue crack propagation. ASTM STP 959. – p. 41 - 60.
42. R. Marissu, K. H. Trautmann and H. Nowack (1984). The influence of compression loads and of dk/da on the crack propagation under variable amplitude loading. Engng Fract. Mech. 21, 453 – 463.
43. Electronic Code of Federal Regulations. Part 23 — Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes [Electronic Code]. — URb: http://www.ecfr.gov/cgi-bin/. — 09.04.2021.

44. Electronic Code of Federal Regulations. Part 25 — Airworthiness Standards: Transport Category Airplanes [Electronic Code]. — URb: http://www.ecfr.gov/cgi-bin/. — 09.04.2021.
45. Electronic Code of Federal Regulations. Part 27 — Airworthiness Standards: Normal Category Rotorcraft [Electronic Code]. — URb: http://www.ecfr.gov/cgi-bin/. — 09.04.2021.
46. Electronic Code of Federal Regulations. Part 29 — Airworthiness Standards: Transport Category Rotorcraft [Electronic Code]. — URb: http://www.ecfr.gov/cgi-bin/. — 09.04.2021.
47. Electronic Code of Federal Regulations. Part 33 — Airworthiness Standards: Aircraft Engines [Electronic Code]. — URb: http://www.ecfr.gov/cgi-bin/. — 09.04.2021.
48. Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes. CS-23. Amedment 3. 20 July 2012. — European Aviation Safety Agency, 2012. — 405 p.
49. Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes. CS-25. Amedment 26. 15 December 2020. — European Aviation Safety Agency, 2020. — 1222 p.
50. Certification Specifications for Small Rotorcraft. CS-27. Amedment 7. 24 June 2020. — European Aviation Safety Agency, 2020. — 169 p.
51. Certification Specifications and Acceptable Means of Compliance for Large Rotorcraft. CS-29. Amedment 8. 24 June 2020. — European Aviation Safety Agency, 2020. — 228 p.
52. Certification Specifications and Acceptable Means of Compliance for Engines. CS-E. Amedment 4. 12 March 2015. — European Aviation Safety Agency, 2015. — 211 p.
53. Linke-Diesinger, Andreas. Systems of Commertial Turbofan Engines. An Introduction to System Functions [Text] / Andreas Linke-Diesinger. — Berlin : Springer, 2008. — 230 p.
54. Kroes, M. J. Aircraft Power Plants [Text] / M. J. Kroes, T. W. Wild. — 7th edition. — Singapore : McGraw–Hill Book Co., 1994. — 694 p.
55. Kroes, M. J. Aircraft Maintenance and Repair [Text] / M. J. Kroes, W. A. Watkins, F. Delp, 6th edition. — Singapore : McGraw–Hill Book Co., 1993. — 648 p.
56. Johnson, N. B. Aircraft Crash Survival Design Guide, Volume V − Aircraft Postcrash Survival [Text] / N. B. Johnson, S. H. Robertson, D. S. Hall. — Report No. USAAVSCOM TR 89-D-22E, US Army Aviation Research and Technology Activity (AVSCOM), Fort Eustis, Virginia, December, 1989. — 205 p.

15. Information Resources

1. Сайт кафедри проектування літаків та вертольотів.: k103@d4.khai.edu
2. www.aviadocs.net.
3. www.avialogs.com.
4. www.mirknig.com.
5. www.eknigi.org.
6. www.twirpx.com.
7. 10.0.0.250\kingi\xai\.