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N.Ye. ZHUKOVSKY NATIONAL AEROSPACE UNIVERSITY

"Kharkiv Aviation Institute"

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АЕРОКОСМІЧНИЙ УНІВЕРСИТЕТ
ім. М.Є. ЖУКОВСЬКОГО

"Харківський авіаційний інститут"

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ПЕРЕОБЛІК 2014р.

**General arrangement
of airplanes**

THE LABORATORY ACTIVITY MANUAL

Загальна будова літаків

МЕТОДИЧНІ РЕКОМЕНДАЦІЇ ДО ВИКОНАННЯ
ЛАБОРАТОРНИХ РОБИТ

Научно-техническая
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**НАУКОВО-ТЕХНІЧНА
БІБЛІОТЕКА**
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General arrangement

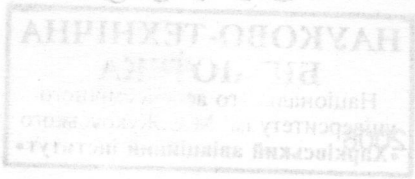
Укладач М.М. Федотов

THE LABORATORY ACTIVITY MANUAL

Заступник будова літаків

МЕТОДИЧНІ РЕКОМЕНДАЦІЇ ДО ВКОНАННЯ

ЛАБОРАТОРНИХ РОБІТ



Kharkiv

Laboratorial activity №1

The load-carrying structure of the wings

The purpose of the activity

The purpose of the work is to expand theoretical knowledge, which was gained on the series of lectures and during self-study of the subject «The load-carrying structure of the wings», and also to study the design features of straight wings, swept-back wings and delta wings of different load-carrying structure, with the help of the full-scale models.

Sequence of operations

Stage 1. Control over the students' knowledge on the theoretical material of «The load-carrying structure of the wings» chapter. For students' self-examination the control questions were adduced.

Stage 2. Study of the structure of the real wings, which are available in the laboratories, is under the teacher's guidance. Herein it is necessary to pay attention to comparison of different wings according to the main design features: plane form, front view, presence of the structural cut off points, load-carrying structure, principle of operation and perception of external loads, nature of skin sharing in the load-carrying work, number of spars, number of wing outlines, arrangement of loads in the wing, capacity utilization, types of joint units, ways of loads transmission on the wing centre section or fuselage, type of high-lift devices and so on. The explanation is accompanied by demonstration of placards, schemes, tables, and charts. After wings perfunctory inspection the teacher will give the individual tasks.

Stage 3. Study of the given text-book with purpose of getting familiar with the contents, features of report drawing up and task execution.

Stage 4. Self-study of the wing structure according to the task and its drafting.

Stage 5. Report drawing up.

Stage 6. Submission of the completed laboratory activity reports to the teacher and passing a test.

Task for independent work

For individual work each student is given wing, available in the educational laboratories of the chair.

Contents of the report

The student must study structures of real wings available in the laboratories, and be able to give the necessary explanations of features of its structure when reporting about completed work to the teacher.

The report on the carried out work should contain:

- sketch of the wing in the plane with the longitudinal and transversal members, ailerons, high-lift devices demonstration;
- sketch of the wing cross-section in the aileron and flap zones;
- sketch of wing attachment points;

When drafting it is necessary to pay attention to the bonding techniques of the skin with framework, spar with ribs, attachment points with longitudinal and transversal load-bearing members.

Test questions

What is the main function of the wing and what are the requirements to it?

How do you define such terms as: wing aspect ratio, wing taper, wing swept angle, airfoil thickness ratio, root and tip chord, wing span?

Describe wing plane form shapes, front view and airfoil.

How do main parameters of a wing affect the structural weight, the aerodynamic strength and stiffness characteristics?

What main advantages and disadvantages of the swept wings and stub wing do you know?

What is the purpose of the variable geometry wing application?

What loads acting on a wing and what kinds of wing strains do you know?

What wing members take shear force, bending moment and torque?

Describe the main load-carrying structure of wings their

specific features and members operation.

What load-carrying members is bending moment in spar-type wings, torsion box-type and monoblock-type wings taken by?

What is the difference between monoblock-type and torsion box-type wing?

Describe the specific feature of swept wings and variable geometry wings structure.

In what way are the forces and moments transferred from wing of different load-carrying structure to the wing centre section or to the fuselage?

Describe the advantages and disadvantages of a swept wing with internal beam?

Explain the main load-carrying structure of a delta wing.

In what way are attachment fittings of or eye-lug and flange joint type designed?

What types of attachment joints are used in spar-type wings, torsion box-type and monoblock-type wings ?

What structural measures are used to avoid flutter and divergence of a wing?

Laboratorial activity №2

Structural members of the wing

The purpose of the activity

The purpose of the work is to expand students' knowledge on structure of wing members, features of their structure and loading. The students will also study the structure of spars, false-spars, ribs, stringers, skin and members of their joints, of different load-carrying structure of real units.

Sequence of operations

Stage 1. Control over the students' knowledge on the theoretical material of «Structural members of a wing» chapter.

Stage 2. Study of the structure of members of real wings, which are available in the laboratories, under the teacher's guidance. Herein it is necessary to pay attention to the comparison of members of different wings according to the main design features:

- to the load-carrying structure, structure and shape of spars, power (force) and forming panels;
- to standard joints of members;
- to materials, of which the basic members of a wing are manufactured, etc.

After control completing each student receives individual task.

Stage 3. Analysis of activity volume, contents of the report and technique of carrying out the work .

Stage 4. Independent study of features of the structure of a real wing structural members according to the task and drawing the sketches.

Stage 5. The analysis of design feature of both the whole wing and its structural members. Make brief technical description of the wing and drawing up the report.

Stage 6. Submission of the completed laboratory activity reports to the teacher and passing the test.

Task for independent work

The individual task for laboratory activity is the study of structural members of an airplane real wing, structural arrangement of which has been studied in laboratory activity №1.

Contents of the report

The student must study structures of structural members of real wings available in the laboratories hall and be able to give the necessary explanations of structural features when reporting about acceptance completed work to the teacher.

The report on the carried out work should contain:

- sketches of spars and false-spars of a wing with the necessary cross-section;
- sketches of normal and reinforced ribs with their shapes and cross-sections drawings;
- sketches of standard joints of structural members (spars, ribs, skin, stringers, false-spars);
- brief technical description of a wing and its structural members.

Test questions

Make a list of structural members of a wing and explain their function.

Describe spars and their function in taking external loads acting on a wing.

What load-carrying structure of spars and false-spars do you know?

How are the ribs subdivided according to their functions in wing load operation?

What load-carrying structure of ribs do you know?

Describe stringers and their function in wing load operation?

With what purpose are technological compensators used in a wing structure?

Describe the wing skin and its function.

Give the classification of skins (stressed-skin, nonstressed-skin, single-layer, sandwich panels etc.).

What are advantages and disadvantages of wing panels (riveted, one piece and sandwich panels)?

How are the ribs in swept and delta wings located? Name advantages and disadvantages of the different design solutions (approaches).

How are wing cut-outs made structurally?

Laboratorial activity №3

Ailerons and high-lift devices of the wing

The purpose of the activity

The purpose of the work is to expand theoretical knowledge, which was gained on the series of lectures and during self-study of the subject «Ailerons and high-lift devices of the wing», and also to study the design features of ailerons structures and high-lift devices, its interior arrangement, control-gears and suspension devices on the full-scale models available in the educational laboratories of the chair.

Sequence of operations

Stage 1. Control over the students' knowledge on the theoretical material of «Ailerons and high-lift devices of the wing» chapter.

Stage 2. Study of the structure of the real airplane units, which are available in the laboratories, under the teacher's guidance. Herein it is necessary to pay attention to the design

differences of the ailerons and high-lift devices of different aircraft: plane form, structural load-carrying configuration, load-carrying work, types of suspension brackets and its structure, kinematics control schemes, types of joint units, members materials, aerodynamic compensation, weight balancing and so on. Then the teacher will give the individual tasks.

Stage 3. Analysis of activity volume, contents of the report and technique of carrying out the work .

Stage 4. Independent study of real units and drawing the sketches.

Stage 5. Make brief technical description of the real units structural arrangement according to the task and drawing up the report.

Stage 6. Submission of the completed laboratory activity reports to the teacher and passing the test.

Task for independent work

For individual work each student is offered high-lift devices and aileron, available in the educational laboratories of the chair.

Contents of the report

The student must study structures of ailerons and high-lift devices available in the laboratories, and be able to give the necessary explanations of features of their structure when reporting about completed work to the teacher.

The report on the carried out work should contain:

- sketches of aileron and selected view of high-lift devices, with the longitudinal and transversal members, suspension brackets demonstration;
- sketches of cross-section of aileron and high-lift devices in suspension brackets zones;
- sketches of cross-section of spars and ribs;
- sketches of standard joints of longitudinal and transversal members and skin;
- sketches of suspension brackets;
- kinematics scheme of control;
- technical description of an aileron and high-lift devices (analysis of structural load-carrying configuration, suspension type, aerodynamic compensation type, weight and aerodynamic balancing presence, answers to the

control questions of the individual task).

Test questions

What is the function of ailerons and how are they located on the wing?

What is the phenomenon of airplane yaw caused by when ailerons are deflected and in what way can it be limited?

What ailerons are called differential?

What does a dropped aileron mean? When and where is it used?

What are aerodynamic balance and weight balancing of an aileron used for? What kinds of aerodynamic balance do you know?

What are the functions of a trim tab and balance tab?

What is the function of spoilers? Explain their purpose and field of application.

Describe the function and kinds of wing high-lift devices. What principles are the operation of wing high-lift devices based on?

What types of flaps do you know?

Are the flaps deflection angles the same at take-off and landing?

What is balancing layer control used for?

How are jet flaps designed and how do they operate? What principles of wing load-carrying capacity are used in this case?

What does Coanda effect mean? Where is it used?

What is the function of slat and leading edge flaps?

What are the deflecting flaps on the fuselage used for?

What loads act on ailerons and wing high-lift devices?

Name the load-carrying structure of ailerons, describe basic members of ailerons structure. How is the cut-out in the aileron nose section for an aileron hinge fitting compensated by?

Explain the structure of aileron hinge fittings.

How many attachment points can aileron have? How are they placed on spanwise?

What do "rigid" and "floating" attachment points or hinge fitting of ailerons mean? In what cases are the ailerons made split spanwise?

Describe the structure of different kinds of wing high-lift devices. Explain the main structural members of wing high-lift

devices and their function.

Describe the structure of attachment joints of wing high-lift devices. How many attachment joints may flap have? In what way does their number influence their structure? How can you determine response of attachment points or support reaction of double-slotted flap extension?

What kinds of actuating high-lift devices do you know?

Laboratorial activity №4

Tail unit (Empennage)

The purpose of the activity

The purpose of the work is to expand theoretical knowledge, which was gained on the series of lectures and during self-study of the subject «Tail unit», and also to study the design features of load-bearing members of fins, stabilizers, all-moving tail unit, elevators and rudders, its suspension and control devices on the members available in the educational laboratories of the chair.

Sequence of operations

Stage 1. Control over the students' knowledge on the theoretical material of «Tail unit» chapter.

Stage 2. Study of the structure of the real airplane units, which are available in the laboratories, under the teacher's guidance. Herein it is necessary to pay attention to comparison of tail unit of different aircraft according to the main design features: plane form, location, structural load-carrying configuration, purpose and structure of load-bearing members and attachment points, load-carrying structure of swivel block and all-moving tail unit, aerodynamic and weight balancing facilities, antibuffet and ant Flutter arrangements and so on. Then the teacher will give the individual tasks.

Stage 3. Analysis of activity volume, contents of the report and technique of carrying out the work .

Stage 4. Independent study of load-carrying structure, arrangement of load-bearing members of the real units and drawing the sketches.

Stage 5. Make brief technical description of the real units according to the task and drawing up the report.

Stage 6. Submission of the completed laboratory activity reports to the teacher and passing the test.

Task for independent work

Under the teacher's guidance student must become familiar with arrangement and structure of load-bearing members of selected unit, available in the educational laboratories of the chair.

Contents of the report

The student must study the report on load-carrying structure, structure members, suspension brackets and control units of the full-scale units of tail unit available in the laboratories, and be able to give the necessary explanations about features of their structure when reporting about acceptance completed work to the teacher.

The report on the carried out work should contain:

- sketches of vertical and horizontal tail fin, stabilizer, (view in plane), with the load-carrying structure, longitudinal and transversal members, rudder and elevator demonstration;
- sketches of cross-section of units in suspension brackets zones;
- sketches of standard members of tail unit structure, with its form and cross-sections, original engineering decisions of some units and standard joints demonstration;
- sketches of rudder and elevator suspension brackets and attachment points of tail unit;
- kinematics control scheme;
- technical description of an unit, answers to the task questions of the individual task.

Test questions

Describe the functions of a tail unit.

What forms (shapes) of a tail unit are used on modern airplane?

What do such terms as stability, controllability and balancing mean?

What methods and facilities of aerodynamic balancing do you know?

What types of tail units are there according to their

arrangement on the airplane?

What kinds of increasing the tail unit efficiency do you know?

Why is the all-moving horizontal tail plane (stabilizer) used on supersonic airplanes?

How is aerodynamic balance of control surfaces defined?

What kinds of aerodynamic balance do you know?

What is control surface mass balance used for? In what way is this balance designed?

What is the function of trim tab and balance tab (servo tab)?

How do they differ?

Describe loading tail units and kinds of their strains.

What load-carrying structure of a tail unit do you know?

What are the functions, features of the structure and design of tail unit load-carrying members?

What load-carrying structure of an all-moving horizontal tail do you know?

How are the attachment fittings of a tail unit and a fuselage designed?

Describe structures and design of control surface, their hinge fitting.

How is buffet and flutter of a tail unit defined?

What measures of avoiding (preventing) them do you know?

Laboratorial activity №5

Fuselage

The purpose of the activity

The purpose of the work is to expand theoretical knowledge, which was gained on the series of lectures and during self-study of the subject «Fuselage», and also to study the arrangement of load-carrying structure of fuselages, hermetic cockpits and its members structure on the full-scale fuselage models available in the educational laboratories of the chair.

Sequence of operations

Stage 1. Control over the students' knowledge on the theoretical material of «Fuselage» chapter.

Stage 2. Study the arrangement of the real airplane units and its structural members, which are available in the

laboratories, under the teacher's guidance Teacher pays his attention to exterior form of different fuselages; truss and semi monocoque fuselages design features and their comparative characteristics; structural joints availability, purpose and operation conditions of longerons, stringers, frames and skin; standard joints of structural members; suspension brackets and attachment points of different units; bounded notches, structure and windows of the cockpit, cabin pressurization and so on. Receiving individual task.

Stage 3. Analysis of contents of the report and technique of carrying out the work .

Stage 4. Independent study of real unit arrangement and drawing sketches.

Stage 5. Make brief technical description of the fuselage section and drawing up report.

Stage 6. Submission of the completed laboratory activity reports to the teacher and passing the test.

Task for independent work

Under the teacher's guidance student must get acquainted in detail with arrangement and structure features of selected full-scale fuselage sections, available in the educational laboratories of the chair, draw their sketches and make their technical description.

Contents of the report

The student must study full-scale fuselage sections, available in the educational laboratories, and be able to give the necessary explanations of structure features when reporting about acceptance completed work to the teacher.

The report on the carried out work should contain:

- sketch of load-carrying structure of the fuselage aft section, with standard and original engineering decisions of some units and structural members demonstration;
- sketch of fuselage cross-section in wing or empennage, nose gear or main landing gear zones;
- sketches of standard joints of the structural members (spars, skin, stringers, frames);
- sketch of main frame structure;
- short technical description of arrangement and load-carrying

structure of the fuselage section.

Test questions

What is the function of the fuselage and what are the requirements imposed on it?

Describe external shapes of fuselages.

Describe kinds of fuselage loading and strains.

What load carrying structure of fuselage do you know? Specify features of their structural members and loading

Describe structure truss fuselages and field of their application.

Explain the load-carrying structure of beam-type fuselages, their arrangement and application.

What factors are taken into consideration when choosing load-carrying structure of fuselage. List the load-carrying structure of fuselage according to the reduction of fuselage structure serviceability.

What is the function of stringers and longerons in beam-type fuselages? Explain the fuselages of their loading and design.

Describe types of frames of beam-type fuselages and their design features. How is the normal frame loaded in case of fuselage bend, in case of fuselage skin stability loss, in case of an operation of excessive internal and external pressure.

Describe the skin of beam-type fuselages, its function and loading.

Explain design of cut-outs in a fuselage.

How are butt joints (attachment fitting) of beam-type fuselages sections of different load-carrying structure designed?

What structure of joints of beam-type fuselages among themselves do you know?

Explain the function, kinds of pressurization and their application.

How is pressurization of cabin and passenger compartments designed?

How are pressurization of windows, doors, hatch and pressure seal designed?

Describe structures of cockpit canopies of airplanes and their glazing.

Laboratorial activity № 6

The landing gear of the airplanes

The purpose of the activity

The purpose of activity is to expand the theoretical knowledge received by students during lectures and self-study work on a theme «The landing gear of the airplanes». There is also studying of the general arrangement, kinematic schemes, design members of the landing gear and the shock-absorbers available in the educational laboratory of the chair. Students must acquaint with constructive solutions of separate units and members of the landing gear and shock-absorbers.

Sequence of operations

Stage 1. Control over the students' knowledge on the theoretical material on a theme «The landing gear of the airplanes».

Stage 2. Studying of the arrangement of real units. The comparative analysis of layout schemes of the planes landing gear and their design features. Reception of the individual task.

Stage 3. Analysis of the report contents and technique of carrying out the work .

Stage 4. Independent study of arrangement of the real units and drawing sketches members of the landing gear and shock-absorbers.

Stage 5. Drawing up of the brief description on the landing gear and the shock-absorber according to the task, registration of activity.

Stage 6. Submission of the completed laboratory activity reports to the teacher and passing the test.

Task for independent work

Under the teacher's guidance the student should study in detail the arrangement, execute sketches and make the brief description on one of the real units available in the educational laboratories of the chair. Each student should study also the arrangement, execute sketches and make the brief description on one of the shock-absorbers available in the educational laboratory.

Contents of the report

The student should study arrangement of the real units and give necessary answers to the teacher's questions on features of their design while passing the carried out work.

The report on the carried out work should contain:

- the sketch of load-carrying structure of the landing gear strut in two projections with the necessary sections explaining its arrangement;
- sketches of the landing gear members – strut, torque links, units of a suspension bracket, locks, etc.
- the sketch of the kinematic scheme of the strut in retraction and extension positions;
- the brief description on the investigated strut of the landing gear and the shock-absorber (type, load-carrying structure, arrangement, design of members, principle of action).

Test questions

Explain purpose of the landing gear and requirements for them.

What loadings and kinds of deformations operate on the landing gear members?

Give the comparative characteristic of schemes for three-basic landing gear with tail and forward struts, the landing gear of bicycle type.

What load-carrying structures of landing gear struts do you know? Name basic members of struts and their purpose.

What is the purpose of torque links, which connect the shock-absorber with the cylinder? What kind of deformation operates on the torque links members?

What types of basic members and features of their application do you know?

What schemes of retraction-extension for the main struts of the landing gear are there?

What schemes of retraction-extension for nose struts of the landing gear do you know?

What types of the wheel suspension on the strut do you know?

What is the difference between levered and semi-levered

suspension bracket?

To what types are shock-absorbers of the landing gear subdivided depending on used elastic and damper members?

What is the operation principle of liquid-gas shock-absorbers?

What structural types of liquid-gas shock-absorbers do you know?

What is the hysteresis (with reference to amortization of the landing gear)?

For what purpose is the initial effort in the shock-absorber of the landing gear created?

What are the arrangement and operation of the liquid shock-absorber?

What are the advantages and disadvantages of rubber and spring shock-absorbers?

Explain the arrangement of aviation wheels and their brakes.

Laboratorial activity №7

Airplane control

The purpose of the activity

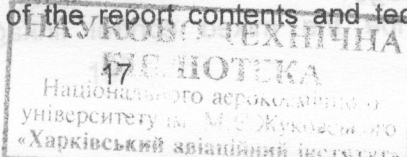
The purpose of activity is to expand the theoretical knowledge received by students at lectures and during independent work on theme «Airplane control», and also studying of the command posts arrangement and structural members of a control system on the real units available in educational laboratory.

Sequence of operations

Stage 1. Control over the students' knowledge on the theoretical material on theme «Airplane control».

Stage 2. Studying of the arrangement of real units of various planes. Thus it is necessary to pay attention to basic schemes of control systems, arrangement of command post of manual and foot control, special mechanisms of control (differential control, nonlinear mechanisms, etc.), designs of members of flexible and rigid linkage the controls convertible and irreversible schemes actuator of control, etc.

Stage 3. Analysis of the report contents and technique of



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carrying out the work .

Stage 4. Independent study of arrangement of the real units and drawing sketches command posts and members.

Stage 5. Drawing up the brief description on units of a control system and registration of activity.

Stage 6. Submission of the completed laboratorial activity reports to the teacher and passing the test.

Task for independent work

Under the teacher's guidance the student should study in detail arrangement, execute sketches and make the brief description on real units of the control system available in educational laboratory.

Contents of the report

The student should study arrangement of real units of the control systems, and answer teacher's questions on their structures.

The report on the carried out work should contain:

- the kinematic scheme of airplane control;
- the sketch of the control stick or control column with constructive decisions of separate units and members;
- the sketch of a foot control post;
- sketches of typical structures of rods, shafts, bellcranks, levers, brackets, guiding devices;
- the brief description on airplane control system and the analysis of a post structures of manual and foot control.

Test questions

Describe purpose and components of airplane control system.

What specific requirements are showed for control systems?

How is independence of control by an elevator (all-moving horizontal stabilizer) and ailerons provided?

What types of control linkages are applied? Name advantages and disadvantages of each type.

Explain the arrangement of flexible control linkage and the structure of its members.

What are the structural members of push-pull mechanical control linkage?

Describe the mixed control linkage and feature of its

application.

What control system refers to differential and what constructive ways it is provided?

For what purpose are nonlinear mechanisms, mechanisms of change gear-ratio in a control system used? Name the specific features of their structure.

For what purpose are loading mechanisms, mechanisms trimmer effect, automatic devices for regulation of control in a control system included? Name the specific features of their arrangement and structure.

Why are actuators in the control system applied?

What kinds of actuators do you know?

Describe convertible and irreversible control systems with the hydraulic actuators, their operation and scope.

In what do features of the arrangement and operation of a control system with rotating rods–shafts consist?

What occurs with ailerons during deflection of the control stick (turn the steering wheel) to the right and what occurs with airplane in this case?

Where does the airplane deviate when pressing the left pedal?

How will the airplane trajectory change during deflection of the control stick or control column to backward?

List

1. M.N. Fedotov. General arrangement of airplanes . – The summary of lectures. – Kharkov: N.Ye. Zhukovsky national aerospace university "KhAI", 2005. – 245 p.
2. Кривцов В.С., Карпов Я.С., Федотов М.Н. Основы аэрокосмической техники. – Х.: Нац. аэрокосм. ун-т "Харьк. авиац. ин-т", 2003. – Ч. 1. – 620 с; Ч. 2. – 901 с.
3. Житомирский Г.И. Конструкция самолетов. – М.: Машиностроение, 1995. – 416 с.
4. Методические указания к лабораторным работам по курсу "Общее устройство самолетов и агрегатов"/ Сост. Л.А. Малашенко. – Х.: ХАИ, 1986. – 77 с.

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