МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Кафедра конструкції літальних апаратів

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
д-р техн. наук, проф.
_____________ С. Р. Ігнатович
«_____» ___________ 2021 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)
ЗДОБУВАЧА ОСВІТНЬОГО СТУПЕНЯ

"БАКАЛАВР"

Тема: «Аванпроект ближньомагістрального вантажного літака»

Виконав: ___________**І.А. Горян**

Керівник: к.т.н., доцент ___________ **В. І. Закієв**

Нормоконтролер: к.т.н., доцент ___________ **С.В. Хижняк**

Київ 2021

MINISRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

Department of Aircraft Design

APPROVED
Head of Department
Professor, Dr. of Sc.
_________S.R. Ignatovych
«___» _______ 2021

DIPLOMA WORK

(EXPLANATORY NOTE)

OF EDUCATIONAL DEGREE

«BACHELOR»

Theme: «Preliminary design of a cargo short-haul aircraft»

Performed by: __________ **I.A. Horian**

Supervisor: PhD, associate professor __________ **V. I. Zakiev**

Standard controller: PhD, associate professor __________ **S.V. Khyzhnyak**

Kyiv 2021

NATIONAL AVIATION UNIVERSITY

Aerospace Faculty

Department of Aircraft Design

Educational degree «Bachelor»

Major 134 "Aviation and space rocket technology"

APPROVED
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«___» _______ 2021

TASK

for bachelor diploma work

HORIAN IVAN

1. Theme: « Preliminary design of a cargo short-haul aircraft»

Confirmed by Rector's order from 21.05.2021 year № 815/ст.

2. Period of work execution: from 24.05.2021 year to 20.06.2021 year.

3. Work initial data: cruise speed V_{cr}= 550 km/h, flight range L = 1100 km, operating altitude H_{op} = 10 km.

4. Explanation note argument (list of topics to be developed): introduction; the project part: choice and substantiations of the airplane scheme, choice of initial data; the calculative part: main parts geometry and aerodynamic calculation, engine selection, aircraft layout, special part: design of the medical module, determitantion of the center of gravity position.

5. List of the graphical materials: general view of the airplane (A1×1); layout of the airplane (A1×1); Medical module (A1×1); layout of the airplane with installed medical modules (A1×1).

6. Calendar Plan

Task	Execution period	Signature
Task receiving, processing of statistical data.	25.05.2021 – 28.05.2021	
Aircraft take-off mass determination.	29.05.2021 – 30.05.2021	
Aircraft centering determination.	29.05.2021 – 31.05.2021	
Graphical design of the aircraft and its layout.	31.05.2021 – 04.06.2021	
Procedure for medical equipment installation and checking.	02.06.2021 – 05.06.2021	
Completion of the explanation note.	06.06.2020 – 07.06.2020	
Preliminary defence	08.06.2020	

7. Task issuance date: 25.05.2021

Supervisor of diploma work ___________ V.I. Zakiev

Task for execution is given for ___________ I.A. Horian

ABSTRACT

Explanatory note to the diploma work «Preliminary design of a cargo short-haul aircraft» contains:

53 sheets, 8 figures, 13 tables, 8 references and 3 drawings

Object of the work is development of the domestic medical aircraft design.

Aim of the diploma work is the development of the medical module and conversion of cargo aircraft into ambulance version.

The method of design is analysis of the prototypes and selections of the most advanced technical decisions.

The diploma work contains drawings of design of the short-range aircraft with commercial cargo payload capacity up to 10000 kg, calculations and drawings of the aircraft layout, the cargo medical compartment and equipment.

PASSENGER AIRCRAFT, PRELIMININARY DESIGN, CABIN LAYOUT, CENTER OF GRAVITY DETERMINATION, MEDICAL MODULE, CENTER OF GRAVITY POSITION CALCULATION.

Format	№	Designation	Name	Quantity	Notes
			General documents		
A4	1	NAU 21 09 H TT	Task of work	1	
	2		Cargo short-haul aircraft	2	
A1		NAU 21 09 H 00 00 09 GV	General view		
A1		NAU 21 09 H 00 00 09 AL	Fuselage layout		
A4	3	NAU 21 09 H 00 00 09 EN	Short-range cargo aircraft	56	
			Explanatory note		
A1	4	NAU 21 09 H 00 00 09 AD	Documentation for assembly units	1	
			Medical module		
			Layout of aircraft with installed		
			medical equipment		

Ch.	Sheet	Doc.№	Sign.	Date	NAU 21 09 H 00 00 09 EN		
Performed by	Horian I.A.				List of diploma work	List	Sheet	Sheets
Supervisor	Zakiev V.I.							
Adviser						AF 402 134		
Stand. contr.	Khyzhnyak S.							
Head. of dep.	Ignatovych S.							

Department of Aircraft Design				**NAU 21 09 H 00 00 09 EN**				
Performed by	Horian I.A.			**Content**	List		Sheet	Sheets
Supervisor	Zakiev V.I.							
Adviser					**AF 402 134**			
Stand. contr.	Khizhnyak S.V.							
Head of Dep.	Ignatovych S.R.							

Department of Aircraft Design				NAU 21 09 H 00 00 09 EN				
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Supervisor	Zakiev V.I.							
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Stand. contr.	Khizhnyak S.V.							
Head of Dep.	Ignatovych S.R.							

1. Project part

1.1 Analysis of prototypes and shirt description of designing aircraft

We are faced with the task of choosing the optimal design parameters of the aircraft. In order to form the appearance of a promising and desired aircraft. This arrangement implies a whole range of characteristics: flight technical, aerodynamic, geometric, weight and economical. And when forming the appearance of the aircraft at the first stage, we use statistical translations of methods, and approximate statistical and aerodynamic dependencies. At the second stage, we use exact formulas for calculating the mass of aircraft units, experimental data and a full aerodynamic calculation.

Aircraft such as AN-26, AN-148, and Boeing YC-14 can and will compete with the projected aircraft in this market segment.

Statistical data are presented in the table 1.

Table 1 - Prototype operational data

Prototype operational data

Parameter	Plane	Plane
-	AN-72 Coaler	B1
Max. paid load, kg	7500	7500
Crew	3-5	3
Accompanying	2	1
Load on the wing, kN/m^2	2,65	2,566

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Average cruising quality	16	16,32
Flight range with $m_{kn\ max}$, km	1000	1100
Range of cruising heights, km	9	9
$V_{cr\ max.}$/H, (km/h)/km	550	550
$V_{cr\ econ.}$/H, (km/h)/km	515	515
Traction, kN/kg	2,6	2,66
Productivity, tkm/h	-	3587
Specific fuel consumption, g/tkm	-	368,181

Power plant data

Number and type of engines	2 (turbojet engines)	2 (turbojet engines)
Takeoff thrust, kN	65	65
Cruising thrust, kN	36	36
Specific fuel consumption (take-off), kg/kN(kW)	34,55	34,55

Specific fuel consumption (cruising), kg/kN(kW)	48,41	48,41
The degree of increase in pressure	20	20
Bypass ratio	5,6	5,6

Takeoff and landing characteristics

Aerodrome base class	-	-
Landing speed, km/h	150,73	150,73
Detachment speed, km/h	168,08	168,08
Acceleration length, m	724	724
Takeoff distance, m	1303	1303
Landing distance, m	790	790

Basic geometric parameters

Wingspan, m	35,8	35,8

Arrow-shaped 1/4 chord, deg	17	17
Average geometric chord, m	3,55	3,55
Wing extension	10,32	10,32
Narrowing of the wing	3,3	3,3
Fuselage length, m	30,8	30,8
Fuselage diameter, m	3,1	3,1
Fuselage extension	9	8,58
Cab width, m	2,15	2,28
Cab length, m	10,5	14
Cab height, m	2,2	2,2
Cabin volume, m^3	280	340
Horizontal tail span	9,69	9,35
Arrow-shaped HT on 1/4 chord, deg	35	35
Relative area of HT,%	-	-
Extension of the HT	3,45	3,45
Narrowing of HT	3	3
The relative area of the PB,%	-	-
Height VT, m	4,93	4,93

Arrow VT on 1/4chord, deg.	40	40
The relative area of VT,%	-	-
Elongation of VT	1,29	1,29
Narrowing VT	1	1
The relative area of PH,%	-	-
Chassis base, m	11,2	9,28
Chassis track, m	3,92	3,92

Table 1

The characteristics of the aircraft depend on its aerodynamic layout and the layout itself. A well-chosen scheme can increase economic efficiency, flight regularity, and aircraft safety. The layout is determined by the interposition of aircraft units, their shape and number.

1.2 Brief description of the main parts of the airplane

1.2.1. Cockpit

The designers managed to achieve a large cargo compartment even with the moderate dimensions of the aircraft itself. Its length is 9 m; width is 2.1 m, and height reaches 2.2 m. Also, on board you can carry any cargo whose weight does not exceed 12.5 tons.

During unloading and loading, a mechanized ramp is used that descends to the ground. It can also be opened during flight for release. Its design was patented in advance, as it received special shear angles, which allows you to throw off containers without losing speed.

1.2.2. Fuselage

The aircraft has an all-metal structure and a sealed fuselage made according to the semi-monocoque scheme with a circular cross-section. The main feature of the case is the implementation of a special technology based on the Coanda effect. If we compare the level of streamlining of the An-72 with the An-26, the advantage of the former will be about 35%.

When creating the case, the designers tried to maximize the strength of the main components. This is due to the increased load provided by powerful engines. It was possible to increase security by using additional power units. This contributed to an increase in the weight of the car, but the problem was immediately solved. The hull elements were created from titanium, aluminum, fiberglass, carbon fiber and other composites, resulting in a weight reduction of 350 kg.

1.2.3. Wing

An-72 was equipped with a high-positioned swept wing. It received a large elongation and enhanced mechanization, consisting of slats, spoilers and two types of flaps. There are also many spoilers installed here to reduce lift during landing. This solution allows you to maintain the balance of the aircraft and prevents it from overturning.

The new technology associated with the Coanda effect affects the wing to a greater extent. During flight, when the flaps and slats are deflected, a powerful jet of gas comes out of the nozzles of the engines. After that, it immediately presses against the surface of the wing and flows around it, accelerating all the air. This high-speed flow reduces air pressure and significantly increases lift. The result is an improvement in the characteristics of the aircraft itself.

1.2.4 Engines

Initially, it was supposed to install a conventional turboprop engine on the An-72, as on the An-26. However, such a decision excluded the possibility of implementing the technology with the Coanda effect, since the blades would leave behind an air jet that physically cannot flow around the wing. After much deliberation, the designers turned their attention to the Yak-42 passenger airliner, which uses a turbojet engine.

As a result, it was decided to install two D-36 turbojet engines on the plane. With their help, it was quite possible to realize all the ideas. Both engines delivered up to 6500 kgf thrust, which was very high and attracted even more attention from the design team. The point is the location of the engines - they are installed in the upper part of the wing.

1.2.5. Landing gear

The designers considered more than 30 landing gear options for the An-72. There was even the idea of installing an air cushion, which would allow the aircraft to become the first transport aircraft capable of landing on water. However, such a solution significantly worsened the aerodynamic properties and would create a number of difficulties in operation.

The ultimate choice was the classic leg-mounted chassis. The front leg is controlled by the pilot and can set the direction of travel. The four main supports, located in pairs under the wing, remained fixed. A distinctive feature of the installed landing gear was the highest strength and improved shock absorption, allowing the aircraft to pass through holes and bumps. After takeoff, they fold into closed doors. If a malfunction occurs, the plane can land even on three extended legs.

1.3 The choice of the layout and parameters of the designed aircraft

The appearance of the aircraft consists of the layout of its parts and assemblies, as well as all types of cargo. The choice of the layout scheme and aircraft parameters is aimed at maximum compliance with the operational requirements.

1.3.1 Calculation of the geometric parameters of the wing

Geometrical characteristics of the wing are determined based on the take-off mass m_0 and the specific load on the wing P_o. First find the area of the wing:

$$Swing = \frac{m_0 \cdot g}{P_0} = 126{,}45*(1-0{,}1) = 120{,}13 \text{ m}^2.$$

The wingspan is calculated by the formula:

$$l = \sqrt{S_{wing} \cdot \lambda_{wing}} = 35{,}21 \text{ m}.$$

Root chord:

$$b_0 = \frac{2 \cdot S_{wing} \cdot \eta}{(1+\eta) \cdot l} = 5{,}24 \text{ m}.$$

And the final chord:

$$b_{wing} = \frac{b_0}{\eta} = 1{,}59 \text{ m}.$$

The side chord for a trapezoidal wing is determined from the:

$$b_0 = \frac{2 \cdot S_{wing} \cdot \eta}{(1+\eta) \cdot l}$$ =4,92 m, where D_f is taken by preliminary calculations.

The maximum thickness of the wing in any section of its span is equal to:

$$C_i = \overline{C} \cdot b_i.$$

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When choosing the power scheme of the wing determine the number of spars and their position, as well as the location of the wing.

Modern aircraft use a caisson wing and two or three spars; one spar wing is used on light sports, ambulance and other aircraft.

The relative position of the spars in the wing on the chord is equal to:

$\overline{X}_i = \frac{X_i}{b}$, where X_i - i-th spar from the toe of the wing, b – chord.

In the wing with two spars: $\overline{X}_1 = 0{,}2; \overline{X}_2 = 0{,}6$.

In the wing with three spars: $\overline{X}_1 = 0{,}15$; $\overline{X}_2 = 0{,}4$; $\overline{X}_3 = 0{,}65$.

This determines the width of the caisson and the capacity of the fuel tanks. The magnitude: b_{cax}=3,55 m. After determining the geometric characteristics of the wings proceed to the evaluation of the geometry of the ailerons and mechanization of the wing. The geometric parameters of the aileron are determined in the sequence:

- Aileron range: l_a= (0,3…0,4) x 1/2=2,39 m;
- Chord aileron: b_a=(0,22…0,26) x b_i;
- Aileron area: S_a=(0,05…0,08) x S_w/2 = 1,71 m^2.

Increasing the recommended values of l_a and b_a is not rational. With increasing l_e above these values, the growth of the aileron moment coefficient slows down, and the scope of mechanization decreases. As the whiteness increases, the width of the caisson decreases.

On the third generation aircraft there was a tendency to reduce the relative scope and area of the ailerons. Thus, on Tu-144 aircraft l_e = 0,122. In this case, in addition to ailerons, interceptors are also used for transverse control of the aircraft. Due to this, the scope and area of mechanization can be increased, which improves the takeoff and landing characteristics of the aircraft.

1.3.2 Determination of geometric characteristics of the fuselage

When choosing the shape and size of the cross section of the fuselage must be based on the requirements of aerodynamics (flow and cross-sectional area).

For passenger and transport aircraft, the speed of which is less than the speed of sound (V<800 km/h), the impedance is almost not affected.

Therefore, the shape should be chosen under conditions of providing the lowest values of the corresponding frictional resistance C_{xf} and profile resistance C_{xr}.

In supersonic flights, the magnitude of the C_{xf} impedance is influenced by the shape of the bow of the fuselage.

The use of a chewy shape of the bow of the fuselage significantly reduces its impedance. For around sound planes, the bow of the fuselage should be: l_{np}=(2…3). D_f – diameter of fuselage.

In addition to taking into account the requirements of aerodynamics when choosing the shape of the section must take into account the layout conditions and strength requirements.

To ensure the minimum weight, the most appropriate cross-sectional shape of the fuselage must be considered a round section. In this case, the thickness of the fuselage sheathing is obtained the smallest. As a variant of such section it is possible to use a combination of two or several circumferences both vertically, and horizontally.

For transport aircraft, when choosing the shape of the cross section of the fuselage issues of aerodynamics do not become paramount and the shape of the section can be performed rectangular or close to it.

The geometric parameters of the fuselage include:

- Diameter of fuselage – D_f;
- Length of fuselage – L_f;
- Elongation of fuselage - $\lambda_{\Phi} = \frac{L_{\Phi}}{D_{\Phi}}$;
- Elongation of the bow of the fuselage - $\lambda_{нч} = \frac{L_{нч.}}{D_{\Phi}}$;
- Elongation of the tail of the fuselage - $\lambda_{хч} = \frac{L_{хч.}}{D_{\Phi}}$.

Where: $L_{нч}$ and $L_{хч}$ - respectively, the length of the bow and tail of the fuselage.

The length of the fuselage is determined taking into account the scheme of the aircraft, features layout and centering, as well as providing a landing angle of attack α_{pos}.

Determine the following parameters of the fuselage: $l_f = \lambda_f \times D_f = 8{,}58 \times 3{,}1 = 26{,}598$ m.

At the stage of sketch design, in the process of preliminary research to determine the length of the fuselage, man can recommend the ratio for aircraft:

- With a straight wing: $L_f/L_{cr} = 0{,}65…0{,}75$ at $\lambda_{cr} = 9…11$; $L_f/L_{cr} = 0{,}75 … 0{,}85$ at $\lambda_{cr}=8$;
- With arrow-shaped wing: $L_f/L_{cr} = 0{,}8…0{,}95$ at $\lambda_{cr}=8…10$; at X^0 – 35…45°: $L_f/L_{cr} = 0{,}95…1{,}25$ at $\lambda_{cr}=3…5$.

When determining the diameter of the fuselage, they strive to ensure the minimum mid-section of the S_{mf} on the one hand and to ensure the layout requirements on the other. For short-haul aircraft, you can take approximately:

- Cabin height (h_1) = 1,75 m;
- Passage width (b_{pr}) = 0,45 ... 0,5 m;
- Distance from the window to the floor (h_2)= 1,0 m;
- The height of the luggage compartment (h_3) = 0,6 ... 0,9 m.

For trunk aircraft, we can accordingly recommend:

- Cabin height (h_1) = 1,9 m;
- Passage width (b_{pr}) = 0,6 m;
- Distance from the window to the floor (h_2) = 1,0 m;
- Luggage compartment height (h_3) = 0,9...1,3 m.

It should be borne in mind that finding the required width of the passenger compartment does not yet allow finding the optimal cross-sectional dimensions of the fuselage. From a design point of view, it is rational to have a round cross section of the fuselage, because in this case it will be the strongest and lightest. However, this form may not always be optimal for accommodating passengers and cargo. It is more expedient to form a cross section of a fuselage in the form of an oval or section of two circles. It is necessary to remember that the oval form is inconvenient in production and the top and bottom panels at excess pressure will work on a bend and will demand introduction of zygomatic beams and other reinforcements in a design. The pitch of normal frames in the construction of the fuselage is in the range from 360 to 500 mm, depending on the size of the fuselage and the class of layout of passenger compartments.

According to the layout understanding at the fuselage diameters less than 2800 mm often deviate from this shape and use the cross section formed by two intersecting circles. In this case, the floor of the passenger cabin is performed in the plane of the arcs.

The windows of the passenger cabin are located in one light line (on the deck by the number of decks). The shape of the windows is round with a diameter of 300...400 mm or rectangular with rounded corners. The step of windows corresponds to a step of frames of 500...510 mm. You also need to check the volume per man. The length of the passenger cabin L_{cab} for placement of the same type of chairs, which are located in N transverse rows with a constant step L_{cr}, can be calculated by the formula:

$L_{cab.} = L_1+(N-1) \times L_{cr} + L_2$, where: L_1 - distance from the plane of the front partition to the first row of seats (mm); L_2 - distance from the plane of the rear partition to the back of the chair (mm).

- 1-th class $V_{pass.} = V_{cab.} / n = 1{,}5\ldots 1{,}8 m^3$;
- Tourist class $V_{cab.} = 1{,}2\ldots1{,}3 m^3$;
- Economy class $V_{cab.} = 0{,}9\ldots1{,}0 m^3$.

The greater the range, the greater the specific volume per man.

1.3.3. Cargo compartments

Cargo compartments can be located on the floor of the passenger cabin or under it in the sealed part of the fuselage. In the first case, the cargo compartments tend to be located in front of and behind the passenger cabin. This approach allows you to adjust the weight of the cargo to ensure the necessary alignment of the aircraft depending on the number of passengers. Locations of cargo compartments are determined when estimating the length of the fuselage; it is recommended to use the data of prototype aircraft.

Approximately the volume of cargo compartments in m^3, located on the floor of the passenger cabin, can be estimated by the formula:

$V_{c.c.}$= 0,0074 $G_{p.w.}$- 0,59$N_{pass.}$$m^3$, where – $G_{p.w.}$ payload weight; $N_{pass.}$ = max. number of passengers.

The payload according to OST 1 00434-81 [15] means the sum of the weight of the commercial load (passengers with luggage, mail, cargo, including the weight of pallets) and the weight of fuel.

When the cargo compartments are located under the floor of the passenger cabin, their volume is determined based on the weight of the cargo and mail and the method of transportation (in containers or on pallets).

For passenger aircraft, the total weight of passengers' baggage, cargo and mail can be determined by the formula:

$G_{cargo} = G_{p.w.} – 77\ G_{pass.}$

Then you can determine the total required volume in m^3 of cargo compartments:

$V_{В.В.} = \frac{15 N_{ПАС.}}{\gamma_{Б.П.}} + \frac{G_{К.Н.} - 90 N_{ПАС.}}{\gamma_{ВАНТ.}}$, where $\gamma_{Б.П.}$- the proportion of baggage and mail (with transportation in containers is assumed to be 250 daN/m^3 at containerless - 120 daN/m^3); $\gamma_{ВАНТ.}$ - the specific weight of cargo (when transported in containers is assumed to be 350 daN/m^3, when containerless - 290 daN/m^3).

Having determined the types and sizes of containers at the stage of forming the cross section of the fuselage and knowing $V_{в.в.}$ you can calculate the total length of the cargo compartments and the number of containers.

Cargo hatches are placed on the starboard side of the aircraft. The dimensions of the hatches for loading containers are chosen in accordance with GOST 1 03625-84.

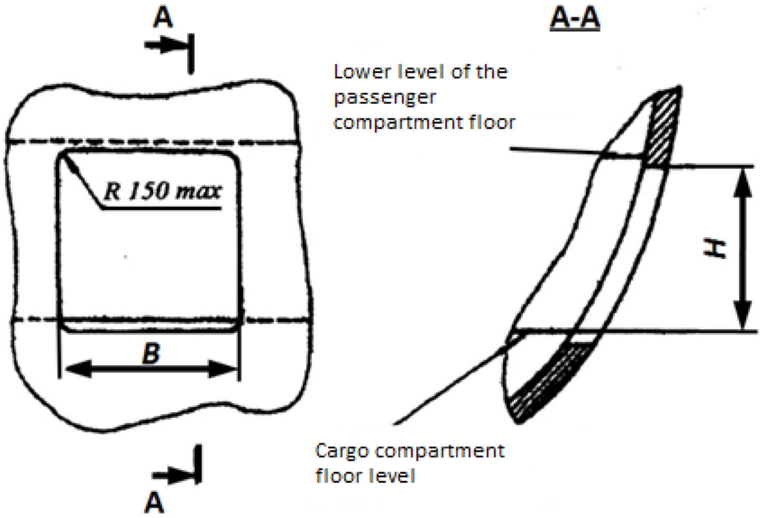

Fig. 1 - The sizes of luggage hatches.

Is easier to calculate as follows:

1) Determine the specific load on the floor of the trunk within K = 400…600 kgs/m^2, take K = 600 kgs/m^2.

2) Determine the mass of almost commercial luggage: $m_{post.}$ = 200 kg, $m_{c.b.}$ =7499,983 kg.

3) Determine according to the formula, the area of the luggage compartment:

$$S_б = \frac{m_{бп}}{0{,}4К} + \frac{m_{гр}}{0{,}6К}$$

4) Required luggage space $V_{бп}$=$V_б$ x $n_{pass.}$ = 0,37 x 0 = 0 m^3;

5) $V_б$ = 0,20...0, 24 – for fuselage $D_f \leq$ 4m;

6) $V_б$ = 0,36...0, 38 – for fuselage $D_f >$ 5,5 m.

e. Calculation of basic parameters and chassis layout.

At the initial design stage, when the centering has not yet been performed and there are no drawings of the general view of the aircraft, only parts of the chassis parameters are determined.

Removal of the main supports of the chassis (Fig. 2.7): e=(0,15…0,20) xb_a.

If the removal is too large, it is difficult to detach the front support during takeoff, and if it is too small, it is possible to overturn the aircraft on the tail when the rear saloons and trunks are loaded first. In addition, the load on the front support will be too small and the aircraft will be shaky when moving on slippery runways and crosswinds.

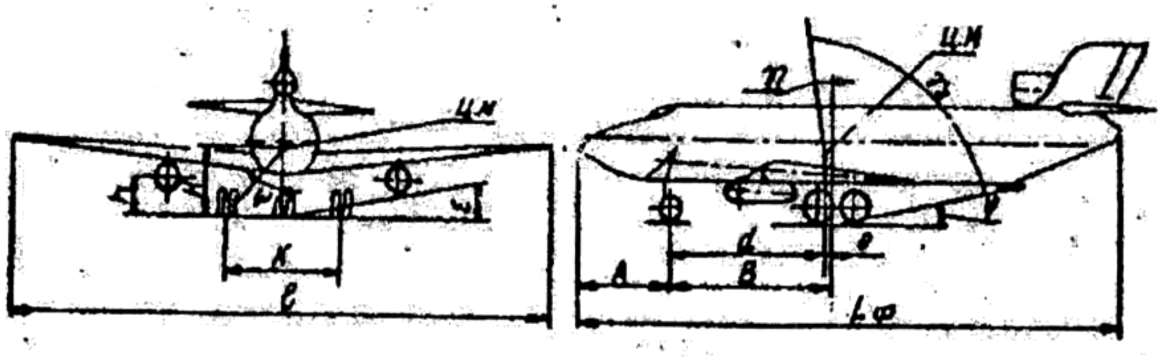

Fig. 2

The base of the chassis is from the equation:

B=(0,3…0,4) x L_f=(6…10) x e= 9,28 m.

Of great importance are aircraft with winged engines (WE). The last equality means that the front support accounts for 6...10% of the mass of the aircraft.

The removal of the front support will be equal to:

d = B – e = (0,94…0,9) x B = 8,64 m.

Chassis track is calculated by the formula:

K=(0,7…1,2) x B $\leq$ 12 m; K=3,92 m.

Chassis wheels are selected from the value of the take-off mass of the aircraft according to the amount of load in the parking lot; dynamic loads are taken into account when selecting the front support wheels.

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The type of tires (balloon, semi-balloon, arch) and the pressure in them is determined by the runway coating, which is intended to operate the aircraft. Brake wheels are installed on the main and sometimes on the front support. Loads on wheels are defined:

- Wheel of the main support: P_{main}=9,81 x (B – e) x m_0/Bnz = 75462,27 (N);
- Wheel of the front support: P_{front}=9,81 x K_d x e x m_0/Bnz=16969,85 (N), where n and z – number of supports and wheels on one support, respectively.
- K_d – coefficient of dynamism.
- According to the calculated value of the load on the wheels R_{main} and R_{front} and the value of the take-off $V_{t.o.}$ and landing $V_{land.}$ speeds are selected according to the catalog of pneumatics, fulfilling the conditions:
- $$P^{К}_{ПНЕВ} \geq P_{ГЛ}; \quad P^{К}_{ПН.ПОС} \geq P_{ПОС}; \quad V^{К}_{ПОС} \geq V_{ПОС}; \quad V^{К}_{ВЗЛ} \geq V_{ВЗЛ}$$
- The index K indicates the value of the parameter that is allowed for the tire in the catalog.

Choosing of the wheel parameters

Main supports (brakes) in mm:	1250 x 510
Front support in mm:	720 x 310

Table 3

If the load on the parking lot specified in the catalog for the selected wheel is more than the estimated 5% or more, then for the coordinated operation of the liquid-gas shock absorber and pneumatics it is necessary to reduce the pressure in the tire to the value: $P = P_0 \frac{P_{CT}}{P^0_{CT}}$, (Pa)

To ensure the possibility of aircraft operated at ground aerodromes, the pressure in the tires of the chassis should be within: p = (3...5) 105 Pa.

1.3.4. Layout and calculation of the main parameters of plumage

One of the most important tasks of aerodynamic composition is the choice of the location of the horizontal plumage. To ensure the longitudinal static stability of the aircraft to overload its CM must be in front of the focus of the aircraft and the distance between these points, attributed to the value of the average aerodynamic chord (AAC) of the wing, determines the degree of longitudinal stability: $m_Z^{Cy} = \overline{X}_T - \overline{X}_F < 0$, where– coefficient of moment.

If m^{Cy}_z = 0, then the aircraft has a neutral longitudinal static stability. If $m^{Cy}_z > 0$, then the plane is statically shaky. In the normal scheme of the aircraft (plumage behind the wing) the focus of the combination "wing-fuselage" when installing the horizontal plumage shifts back, in the scheme "duck" (plumage in front of the wing) - forward. Statistical ranges of values of coefficients of static moments of horizontal A_h and vertical A_v of plumage are given in tab. 9, where L_{hw} / b_a and L_{vw} / b_a - the characteristic ratio of the shoulders of HW and VW to the AAC of the wing. Using table. 4, it is possible to determine in the first approximation geometrical parameters of plumage.

Ranges of values of static moments of plumage

Types of aircraft	A_{hw}	A_{vw}	$\frac{L_{ГО}}{b_A} = \frac{L_{ВО}}{b_A}$
Main passenger with turboprop	0,8…1,1	0,05…0,08	2,0…3,0

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Trunk passenger with jet engine	0,65…0,8	0,08…0,12	2,5…3,5
Heavy non-maneuverable with an arrow-shaped wing	0,5…0,6	0,06…0,1	2,5…3,5
Heavy non-maneuverable with a straight wing	0,45…0,55	0,05…0,09	2,0…3,0
	0,4…0,5	0,05…0,08	1,5…2,0

Table 4

The value of the geometric parameters:

Significantly areas of vertical S_{vw} and horizontal S_{hw} plummet store:

S_{hw}=(0,18…0,25) x S; S_{vw}=(0,12…0,20) x S;

The designation of the area of the steering wheels and straight:

The area of the rudder height is usually taken: S_{rh}=(0,3…0,4) x S_{hw}=8,725m^2.

The area of the direction is usually accepted: S_d= (0,35…0,45) x S_{vw}=7,517m^2.

Choice of aerodynamic compensation area:

The area of aerodynamic compensation should be taken (at $0,3 < M < 0,6$);

$S_{ac.rh}=(0,22\ldots0,25) \times S_{rh} = 1,7\ m^2$;

$S_{ac.d}=(0,2\ldots0,22) \times S_d = 1,35\ m^2$.

If the flight speed $M\geq0,75$, then $S_{ac.rh} \approx S_{ac.d} = (0,18\ldots0,23)\cdot S$.

In order to prevent overcompensation of the rudders, the following requirements must be met:

$$\frac{S_{AK.PB}}{S_{PB}} = \frac{S_{AK.PH}}{S_{PH}} \leq 0,3$$

Area of trimmers for height rudders: $S_{tr.hr} = (0,08\ldots 0,12) \times S_{rh}$, and for the rudder of the aircraft with two engines: $S_{tr.te} = (0,04\ldots0,06) \times S_{rh}$, for an aircraft with four engines $C_{tr.te} = (0,06\ldots 0,10) \times S_d$.

Determination of the range of horizontal plumage: The wingspan and plumage of the aircraft are statically dependent: $l_{hw} = (0,32\ldots0,5) \times l_w=9,35$ m.
In this dependence, the lower limit corresponds to aircraft with turbojets equipped with a rotating stabilizer. The height of the vertical plumage h_{hw} is determined depending on the location of the wing relative to the fuselage and the location of the engines on the aircraft. Taking into account the above take:

- for low-flying aircraft with wing engines (at $M<1$): $h_{vw} = (0,14\ldots0,2) \times l_w$;
- when placing the engines in the root of the wing $h_{vw} = (0,13\ldots0,14) \times l_w$;

At the top arrangement of a wing concerning a fuselage in the recommended ranges it is necessary to take the upper limit; $h_{vw} = 4,93$ m;

Narrowing of horizontal and vertical plumage should be chosen:

$\eta_{го} = 2\ldots3$ і $\eta_{во} = 1\ldots1,33$ – for planes with $M<1$

$\eta_{го}$ = 2…4 і $\eta_{во}$ = 2…5 – for planes with M>1

$\eta_{го}$ =3 , $\eta_{во}$ =1;

We can recommend:

- for aircraft whose speed is less than the speed of sound: $\lambda_{во}$=0,8…1,5; $\lambda_{то}$=3,5...4,5
- for aircraft whose speed is faster than the speed of sound: $\lambda_{во}$=1,5…2,5; $\lambda_{то}$=2,5...3,5

Definition of chord plumage performs according to the formulas:

- Chords of plumage HT: $b_{КІНЦ} = \dfrac{2 \cdot S_{ГО}}{(\eta_{ГО}+1) \cdot l_{ГО}} =$ 1,35 м

$$b_{САХ} = 0{,}66 \cdot \frac{\eta_{ГО}^2 + \eta_{ГО} + 1}{\eta_{ГО} + 1} b_{ГО\ КІНЦ} = \quad 2{,}90 \text{ м}$$

$$b_{КОРН} = b_{КОНЦ} \cdot \eta_{ГО} = 4{,}06 \text{ м}$$

- Chords of plumage VT: $b_{КІНЦ} = \dfrac{2 \cdot S_{ВО}}{(\eta_{ВО}+1) \cdot l_{ВО}} =$ 3,81 м

$$b_{САХ} = 0{,}66 \cdot \frac{\eta_{ВО}^2 + \eta_{ВО} + 1}{\eta_{ВО} + 1} b_{ВО\ КіНЦ} = 3{,}77 \text{ м}$$

$$b_{КОРН} = b_{КіНЦ} \cdot \eta_{ГО} = 3{,}81 \text{ м}$$

Relative profile thickness: for horizontal or vertical plumage in the first approximation. More precisely, taking into account the characteristics of aircraft:

- for aircraft whose speed is less than the speed of sound C = 0,08…0,10;
- for transonic aircraft C = 0,06...0,09;
- for supersonic aircraft of the normal scheme C = 0,03...0,04;
- for supersonic aircraft scheme "duck" C = 0,02.

In the case of mounting the stabilizer on the keel, it is necessary to take the value along the upper limit to provide the base for mounting the stabilizer on the keel.

Arrow-shaped plumage: The arrow-shaped plumage is taken 3...5° more than the arrow-shaped wing. This is done to ensure the controllability of the aircraft with the appearance of a wave crisis on the wing.

1.4. Determination of the aircraft center of gravity position

When performing the volume-mass layout, calculations of aircraft centering are performed, i.e. finding such a position of the center of mass (CM) of the aircraft relative to the geometric mean chord of the wing, in which:

- In the case of the variant with the rearmost position of the CM, the minimum allowable margin of static stability of the aircraft is provided;
- In the case of the variant with the most forward position of the CM, the conditions of sufficiency of deviation of the rudder or stabilizer for longitudinal balancing of the aircraft in all flight modes are provided;
- The more efficient the longitudinal control and balancing of the airplane, the greater may be the permissible frontal alignment and, consequently, the wider the permissible operating range of the alignments.

During the operation of the aircraft, the position of its CM changes both as fuel is produced in flight and as a result of different loading options and flight masses.

Therefore in KP it is necessary to calculate ranges of centering of the plane for the most characteristic cases of its operation:

- Takeoff mass when the chassis is released;
- Takeoff weight with the chassis removed;
- Landing weight with the chassis released;
- Distillation option (without commercial load at maximum fuel) with the chassis removed;
- Parking option (without commercial load, fuel, and crew) with the chassis released.

The calculation of the centering of the aircraft is usually an iterative process, which is performed by the method of sequential approximation to the desired result or by changing the layout, or permutation of groups of masses, or using both options simultaneously.

When performing KP alignment is determined by the x-axis, along the fuselage (Fig. 9.). The initial data for the calculation of alignments are the mass statement, theoretical drawing and preliminary layout of the fuselage, wings, plumage, and chassis. The drawing must be performed on one of the scales in accordance with current standards: 1:10; 1:15; 1:20; 1:25; 1:40; 1:50; 1:75; 1: 100; 1: 200.

Before the direct determination of the alignment is a statement of the masses of the aircraft. It includes the masses mi of the main parts and units of the aircraft, including fuel and cargo. Keep in mind that on modern subsonic aircraft fuel is placed in wing caissons, sometimes on long-haul aircraft, additional tanks are placed in vertical or horizontal plumage.

The mass summary is made in the form of a table - a centering statement, which includes the coordinates of the centers of mass of all components of the takeoff mass of the aircraft relative to the bow of the fuselage x_i, as well as static moments of mass $m_i x_i$ (Tables 3.1, 3.2.). To determine the coordinate's x_i, a schematic drawing of the previous variant of the aircraft layout should be used.

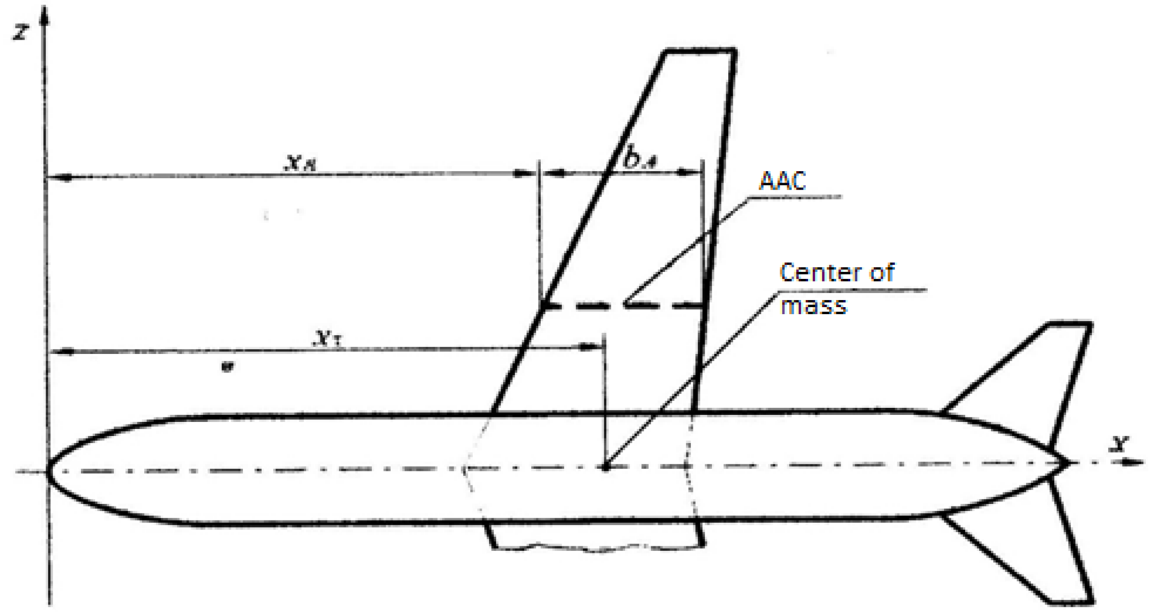

Fig. 2 - Determination of the center of mass of the equipped wing.

The mass of the equipped wing includes the mass of its structure, part of the mass of the equipment (located in the wing), the chassis and the mass of fuel. Regardless of where the main chassis supports are located (on the wing or on the fuselage), they are included in the centering mass of the equipped wing together with the front support (Table 3.1.). The origin of these coordinates of the centers of gravity of the masses is chosen in the projection of the starting point of the AAC on the XOY plane. The names of the object, their relative and absolute masses and the coordinates of the centers of mass are entered in the centering statement. The coordinates of the centers of mass of fuel in each tank (group of tanks) are (see appendix).

- behind the chord of the wing - in the middle of the caisson;
- by wing span - at a distance z from the inner, relative to the plane of symmetry of the aircraft, the tank wall z = 0,45 l_t, where l_t – length of the wall of fuel tank on the scope of the spar.
- Relative mass of fuel that can be placed in the fuselage (centerplane wings): $\overline{m}_{\text{п ф}} = \overline{m}_{\text{п}} - \overline{m}_{\text{п кр}}$, The relative mass of fuel that can be placed in the wing: $\overline{m}_{\text{п кр}} = \frac{\beta \overline{c}_{\text{кр}}}{\lambda_{\text{кр}}^{0,5}} \frac{m_0^{0,5}}{p_0^{0,5}}$, where β = 220+15$\eta_{\text{кр}}$ – coefficient, which depends on the narrowing of the wing.

The coordinates of the center of mass of pylons, engines, nacelles are determined graphically by the centering drawing of the wing. In the table. 3.1. Provides an approximate list of objects of mass and recommendations for determining the coordinates of their centers of mass.

1.4.1. Centering of the mass of the equipped wing

№	Name of object	Mass m_i ,kg		The coordinate center mass x_i, m	Static moment of mass m_i,x_i, kgm
		relative	absolute		
1.	Wing (construction)	0.16286	5386.76	1.46	7845.89
2.	Fuel system (1.5%...2%) from m_n	0.0023752	78.56	1.46	114.43

3.	Aircraft control system (30%)	0.0022	91.29	1.94	177.29
4.	Electrical equipment (10%)	0.0022	72.77	0.32	23.55
5.	Frost protection system (70%)	0.008771	290.11	0.32	93.90
6.	Hydraulic system (70%)	0.01617	534.84	2.27	1211.78
7.	The main engines	0.03884	1284.67	-3.12	-4008.18
8.	Engine equipment, fastening units	0.020196	668.03	-0.12	-77.36
9.	Fire protection system	0.0132056	436.79	-0.12	-50.58
Equipped wing (without fuel and chassis)					
10.	The main supports of the chassis	0.036488	1206.88	1.62	1953.15

11.	Fuel (including air navigation stock)	0.11876	3928.11	1.46	5721.34
Total			13978.8	0.93	13005.22

Table 5

Notes. 1. Numbers of names of objects of the centering statement of masses of the equipped wing should correspond to ordinal numbers on the centering drawing of a wing. 2. The calculation of all groups of masses is carried out according to the computer program of the Department of Aircraft Design. The coordinate of the center of mass of the equipped wing is determined by the formula

$$x_{KP.} = \frac{\sum m_i x_i}{\sum m_i}$$

1.4.2. Determination of the center of mass of the equipped fuselage

The origin is chosen in the projection of the bow of the fuselage on the horizontal axis (see appendices). The construction axis of the fuselage is taken as the x-axis. An approximate list of objects of mass and recommendations for determining the coordinates of their centers of mass are given in table. 1.4.2.1.

Centering sheet of the masses of the equipped fuselage

№	Name of object	Mass m_i		The coordinate center mass x_i, m	Static moment of mass m_i,x_i, kgm
		Relative	Absolute		

GLIDER					
1.	Fuselage (construction)	0.16579	5483.67	12.77	70010.23
2.	Horizontal plumage	0.02515	831.86	26.07	21689.37
3.	Vertical plumage	0.02907	961.52	26.07	25069.98
EQUIPMENT AND MANAGEMENT					
4.	High-altitude equipment	0.00537	177.62	12.24	2173.17
5.	Frost protection system (30%)	0.003759	124.33	12.77	1587.36
6.	Passenger equipment	0.001	33.08	2.66	87.98
7.	Decorative cladding	0.0091	300.99	13.03	3922.83
8.	Cargo equipment	0.0103	340.68	13.30	4530.74
9.	Hydraulic system (30%)	0.00693	229.22	13.30	3048.35
10.	Electrical equipment (90%)	0.0198	654.90	10.64	6967.66
11.	Location equipment	0.006	198.46	2.13	422.28

12.	Navigation equipment	0.009	297.68	1.33	395.89
13.	Radio communication equipment	0.0045	148.84	1.33	197.94
14.	Instrument equipment	0.0105	347.30	1.06	369.50
15.	Aircraft control systems (70%)	0.00644	213.01	13.30	2832.81
16.	Auxiliary power plant	0.0054376	179.85	8.73	1570.72
Empty fuselage			10523.02	13.77	144876.83
EQUIPMENT					
17.	Crew		285.00	2.66	758.04
18.	Flight attendants		75.00	2.66	199.49
19.	Documentation and tools	0.003	99.23	1.86	184.75
20.	Water (chemical gen.)		8.00	12.77	102.14
21.	Additional equipment	0	0.00	10.64	0.00
Empty equipped fuselage			10990.24	13.30	146121.24
22.	Front chassis support	0.009122	301.72	4.00	147328.12

Total		11297.96	13.05	147328.12
COMMERCIAL LOADING				
23.	Baggage	7500	12.77	95752.80
Total		18851.58	12.94	243905.44

Table 6

Determined the centers of mass of the equipped wings and fuselage is the equation of equilibrium of moments relative to the bow of the fuselage $m_ф x_ф + m_{кр}(x_a + x_{кр}) = m_0(x_a + x_c)$. As is known, the centering of the aircraft $x_t = x_a + c$ is the coordinate of the position of its center of mass in the projection on the middle aerodynamic chord of the wing. It can be defined from the previous formula as $\overline{x}_т = \frac{m_ф x_ф + m_{кр}(x_a + x_{кр})}{m_0}$

In practice, the centering of the aircraft is determined, as a rule, in relative coordinates (x_t), i.e. the position of the CM of the aircraft from the beginning of the , expressed as a percentage (or fraction) of the MAC

$$\overline{x}_T = \frac{x_T - x_A}{b_A} 100\%$$

Thus, to calculate the alignment of the aircraft (x_t) it is necessary to know the position of the beginning of the AAC wing relative to the bow of the fuselage x_a. The initial value of x_a can be determined through the appropriate scale from the scheme of the prototype aircraft, pre-determining the value of the MAC and drawing it on the wing.

As a result of the calculations should be obtained values of the alignments of the aircraft, which are given in table 7.

The value of aircraft alignment according to statistics

Straight wing		Arrow-shaped wing	
Low-wing	High-wing aircraft	Low-wing	High-wing aircraft
13…32	15…33	18…38	20…42

Table 7

If these values cannot be obtained, it is recommended to use the following centering adjustment tools: change the location of the heaviest loads in the fuselage; move the wing along the fuselage (this will move not only the center of mass of the aircraft, but also the MAC of the wing).

In order to determine the distance l to move, for example, the wing of the aircraft as the largest unit of the aircraft, you must first determine how much you need to change the alignment (Δx_t) in order to obtain the recommended values. The value (Δx_t) is defined as the difference between the calculated and recommended values (x_t). The distance l is as

$$l = \frac{\Delta \bar{x}_T b_a m_0}{m_{кр}}$$

To increase x_t it is necessary to subtract the value of l from the initial value of x_a, then it is necessary to list the alignment of the aircraft with the new value of x_a. In order to facilitate the calculations of alignment options, it is recommended to reduce the masses and the corresponding coordinates of the masses in the table.

3.4. Mandatory variants of aircraft centering calculations for the most typical cases of aircraft operation are summarized in Table. 3.5. When performing alignment calculations, it is necessary to check compliance with the requirements: $\sum m_o = m_{спор.\ кр.} + m_{спор.\ ф.}$; $L_{го} \geq 3b_a$

For the landing option, the mass of fuel can be approximately taken 15% ... 20% (depending on the type of aircraft) of the mass of fuel during takeoff, and for distillation - the mass of fuel is possible (due to lack) commercial load) and is determined by the capacity of the fuel tanks of the aircraft. The centering process is considered complete only after the alignment values for the most typical aircraft operation options fall within the recommended ranges.

1.4.5. Summary centering statement

№	Name of object	Mass m_i, kg	The coordinate center mass x_i, m	Static moment of mass, m_i,x_i, kgm
1.	Equipped wing (without fuel and chassis)	8843.81	0.60	5330.72
2.	Chassis front support (released)	301.72	4.00	1206.88
3.	Main chassis supports (released)	1206.88	1.62	1953.15
4.	Fuel	3928.11	1.46	5721.34
5.	Empty equipped fuselage	10990.24	13.30	146121.24
6.	Passengers	0.00	13.56	0.00
7.	Food	59.61	13.83	824.52

8.	Front chassis support (removed)	301.72	3.50	1056.02
9.	Main chassis supports (removed)	1206.88	1.62	1953.15

Table 8

Options for centering the aircraft

№	Name of variant	Mass m_i, kg	Static moment of mass x, m	The center of mass of the aircraft x, m	Centering [illegible]
1.	Takeoff weight (chassis released)	32830.37564	256910.66	12.78	28.53
2.	Takeoff weight (chassis removed)	32830.37564	256759.80	12.77	28.39
3.	Landing weight (chassis released)	30038.6	252486.68	12.72	26.87

4.	Distillation (without commercial load, chassis removed)	25270.8	160182.48	12.90	32.20
5.	Parking (without commercial load, fuel, crew, water, chassis released)	20875.4	153367.5792	13.05	37.09

Table 9

Conclusion to the project part

In this part, the main parameters of the projected aircraft were determined, all its nodes, structural elements, and their characteristics were described. Also, the center of gravity of the projected aircraft was calculated and determined, the center of mass without equipment, as well as with it.

It is a light jet military transport aircraft with a short takeoff and landing, twin-engine. The design of the An-72 is all-metal, composite materials are widely used. The fuselage is sealed, semi-monocoque type, circular section. The wing has a large aspect ratio, arrow-shaped, trapezoidal in plan. The wing is mechanized using spoilers, slats, three-slot cantilever and two-slot center-wing flaps. The stabilizer was also equipped with a slat. The internal sections of the flaps are blown with gas jets of the engines.

The aircraft has a five-support, retractable landing gear (4 main and 1 nose struts). The power plant includes the APU TA-12 and 2 turbofan engines D-36. There is a large cargo hatch in the aft fuselage, it is closed by a ramp that can slide under the bottom or drop to the ground. The cargo compartment is equipped with mooring devices, a crane-beam.

Designed with engines mounted above the wing to take advantage of the Coanda effect - an increase in lift by “sticking” the exhaust jet to the wing. It stands out for its highly mechanized wing with trapezoidal consoles and a straight center section. The aircraft is equipped with an efficient bucket-type reverse, a powerful landing gear with independent suspensions of the main struts and a cargo hatch with a ramp.

2. Special part

Air ambulance, or otherwise - medical evacuation by air, is a modern and promising branch of intensive medicine. The development of air ambulance has made a real breakthrough in helping people affected by natural disasters, wars and road accidents. Specialists of intensive medicine have long proven that the time factor plays an important role in preserving a person's life. In other words, the sooner the patient receives qualified medical care, the more chances he has for recovery, and sometimes even for survival.

2.1. The history of the creation of ambulance aircraft

The first aircraft in Ukraine, which were developed for sanitary purposes, were the K-1, K-2 and K-3 passenger aircraft models, developed by Konstantin Kalinin. In the 1920s, Kalinin, while working at an aircraft repair plant in Kiev, designed the K-1 single-engine four-seated monoplane, which in 1925 took to the skies for the first time and was approved for use in civil aviation. After that, Kalinin was invited to Kharkov as the chief designer for the creation of five aircraft commissioned by Ukrpoitrostroy for use in sanitation. The K-2 aircraft, manufactured in 1927, became a conventional five-seat passenger aircraft, and the K-3 became the first specialized ambulance aircraft. The aircraft was designed to accommodate two patients on a stretcher, as well as a medical attendant, while flying the aircraft's full load range of 680 km.

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Performed by	Horian I.A.			Special part	List	Sheet	Sheets
Supervisor	Zakiev V.I.						
Adviser					AF 402 134		
Stand. contr.	Khizhnyak S.V.						
Head of Dep.	Ignatovych S.R.						

Fig. 3 - medical Kalinin K-3 aircraft

Subsequently, for the needs of sanitation, they began to use the An-2, developed under the leadership of Oleg Antonov. The biplane was widely used for both civil and military aviation. One of the modifications was designed specifically as an ambulance plane that could carry up to six wounded on a stretcher. The aircraft cockpit was also equipped with first aid kits, an irrigation spot and a portable bathroom. Until 1977, such ambulance aircraft did not have the ability to carry out medical manipulations or resuscitation of the wounded and sick. Therefore, the aircraft An-26M "Rescuer" was created, which was already equipped with medical equipment, which made it possible to carry out emergency resuscitation and surgical care on board. In the compartments of the cargo compartment of the aircraft there were apparatus for artificial respiration, anesthesia, blood transfusion, etc.

Fig. 4 - medical An-26 “Rescuer”.

In the early 2000s, a medical version of the An-26 "Vita" was created on the basis of the An-26. The need for such a "flying hospital" was realized thanks to the armed conflicts of the last decades in the world. This aircraft with the appropriate specialization and departments (operation, resuscitation, separate compartments for medical personnel and household needs) allows you to provide full medical care on board. Contents of four severely injured or 12 sedentary patients. For uninterrupted medical care, the aircraft is equipped with an additional power plant (generator). The aircraft is in service with the 456th Air Brigade of the Ukrainian Air Force. Before the outbreak of the war in 2014, one medical aircraft was sufficient for rescue operations.

2.2. Analysis of existing medical aircraft

An ambulance plane has significant differences from ordinary passenger aircraft. Depending on the severity of the patient's condition, his age and diagnosis, medical units are deployed inside the aircraft, with all the necessary equipment: tracking equipment, an artificial respiration apparatus, and systems for the constant supply of medicines. The patient is taken on board and accompanied in flight by a trained team of medical specialists. The medical staff carries out not only the technical delivery of the patient to the destination, but continues the treatment and supports the life support of the person during the flight. The qualifications of doctors and the level of equipment allow transporting newborn children and babies.

The aircraft are designed for various flight ranges and are fully equipped with the necessary medical equipment.

Specialized aircraft of the medical service:

Fig. 5 - Lear Jet 35/31, with a flight range of about 3000 km.

Fig. 6 - Piper Cheyenne, with a flight range of about 1300 km.

Arrangement and equipment of a medical service aircraft

Depending on the specific clinical case on board the medical aircraft, it is possible to deploy the following blocks:

- Intensive care unit.
- Resuscitation unit (including the necessary equipment for artificial ventilation of the lungs and resuscitation measures).
- Intensive care unit for premature and newborn babies, including incubators and neonatal monitors.

The experience of using aviation for medical purposes in recent decades shows that the use of specialized medical modules quickly installed on board in multifunctional aircraft can significantly increase the economic efficiency of using aircraft compared to highly specialized medical such as "flying hospital" with stationary medical equipment in a specially modified cabin. In this regard, it is necessary to pay attention to aviation medical modules of well-known world manufacturers, which are not certified for use on domestic aircraft, but are actively promoted, to the domestic market “as is”. This leads to the need to revise these modules in terms of pneumatic and electrical connectors, the main fasteners. As a rule, it is required to install additional attachments to the board to exclude resonance vibrations in an aircraft “non-native” for this module. In turn, this entails additional tests, the development of new documentation, the costs of which, as well as the subsequent registration procedure, are borne by the domestic buyer of this module. In the event of any technical or medical emergency situations, if the use of medical devices that do not have documents confirming the compliance of these products with the operating conditions on board an aircraft (in terms of resistance to mechanical stress, electromagnetic compatibility, etc.) medical products of a registration certificate giving the right to be used in medical practice on the territory of Ukraine, liability arises in accordance with the legislation of Ukraine.

2.3. Requirements for medical aircraft

Sanitary aviation is a specific type of air transportation, which implies transportation of a patient (including emergency) to any part of the world on specially equipped vehicles, accompanied by highly professional medical personnel. The organization of the flight is carried out individually according to the needs of the patient and taking into account the state of his health.

The main characteristics of air ambulance include: equipping aircraft with special devices - dropper racks, electronic equipment, intensive care modules, aids; the presence on board of experienced resuscitators and other medical personnel - in case the patient needs urgent medical attention; the presence on board of special units that maintain an optimal microclimate - humidity and air temperature; the availability of equipment to support the patient's life - stretchers, defibrillators, ventilators and others; when placed on board, all devices and devices are securely fixed with the help of special clamps, and therefore do not create problems during the flight; the aircraft is operated by an experienced flight crew. The control is carried out as accurately as possible, without turbulence, shaking and other problems that can negatively affect the patient's condition. The flight, which is to be performed at such absolute altitudes, at which the atmospheric pressure in the cabins of passengers and flight crew will be less than 700 hPa, begins only if there is a sufficient supply of oxygen on board for breathing:

- For all crew members and 10% of passengers for any period in excess of 30 minutes when the pressure in their cabins is between 700 hPa and 620 hPa.
- For the crew and passengers during any period when the atmospheric pressure in the cabins occupied by them is less than 620 hPa.

A flight to be operated by an aircraft with pressurized cabins begins only if there is sufficient breathing oxygen on board for all crew members and passengers - depending on the conditions of the flight being performed - in the event of a depressurization during any period of time when the atmospheric pressure in any cabin they occupy will be less than 700 hPa. In addition, if the aircraft is flying at absolute altitudes at which the atmospheric pressure is below 376 hPa, or if the aircraft is flying at altitudes at which the atmospheric pressure exceeds 376 hPa, and cannot safely descend within 4 minutes to absolute altitude, with an atmospheric pressure of 620 hPa, at least a 10-minute supply of oxygen is provided for occupants of the passenger cabin.

When it becomes necessary to resort to air ambulance:

- The severity of the patient's condition does not allow choosing a different method of transportation.
- The clinic is located at a considerable distance.

Loss of time threatens to worsen the patient's condition or risk life.

Currently, thanks to trained specialists and equipped transport, it is possible to safely evacuate people with a variety of serious diseases by air. The list of ailments and pathological conditions in which the patient was successfully delivered by air is very wide:

- Acute trauma;
- Coma of various origins;
- Paralysis after injury and CNS disease;
- Injuries to the spine (including the cervical spine);
- Pelvic injury;
- Aortic aneurysm;
- Dissection of the walls of arterial vessels;

- Brain tumors;
- Severe heart disease;
- Septic shock;
- Cancer of the stomach and pancreas;
- Internal bleeding;
- Liver abscess;
- Purulent-inflammatory diseases of soft tissues.

The transportation of premature babies and newborns with low body weight or a serious general condition is always fraught with a number of difficulties. Such a baby needs a special microclimate, it is also important not to interrupt treatment and to monitor vital functions. Modern ambulance planes have on board incubators (incubators for newborns) and the necessary equipment for therapy.

3.3 Brief description of the chosen medical module

The main advantage of medical modules installed in helicopters and airplanes is that they are equipped with modern and reliable medical equipment. The disadvantages are limited use, as well as significant weight (about 300 kg), long installation time, the need to disconnect the patient from life support systems to move to another compartment.

The aircraft I designed has 3 modules on each side of the fuselage, which gives a total of 6 wounded or critically ill patients + medical personnel. These medical modules are equipped with everything necessary for resuscitation, provision of emergency medical care to victims, maintenance of the life of a patient in critical condition before transporting him to a medical institution at a distance of up to 1100 km from the place of evacuation. During transportation, the module allows you to monitor the basic functions of life and, if necessary, conduct intensive therapy. This is exactly what we need these kinds of planes for.

Medical module MM-148.9520.000 is a stretcher with built-in equipment and medical containers.

Fig. 7 – Medical module MM-148.9520.000.

Main technical characteristics:

- Overall dimensions: 1940x724x1436 (1131) mm;
- Mass of the module complete with medical equipment: 115 kg;
- Maximum number of modules placed: in the AN-148 / AN-72 aircraft: 6 pcs;
- Power supply of the module from the on-board DC network;
- Voltage: 27V;
- Power consumed by medical equipment of one module, no more than 650W;
- Total power consumed by one medical module, no more than 1000 W;

The module provides:

- Pressure of medical oxygen, Mpa (kgf / cm2): 0.49 (4.9);

- Installation and connection of oxygen cylinders at the same time: 4 pcs.;
- Capacity of one oxygen cylinder, 5 L;
- Duration of continuous operation of medical equipment from built-in batteries, not less than 2 hours.
- Possibility of loading (unloading) on ground vehicles using airfield ground handling equipment, as well as loading and unloading from aircraft.

The composition of the medical module:

1. Monitoring and defibrillation system corpuls3;
2. Electrocardiographs SCHILLER, performed by “CARDIOVIT AT 101”;
3. Sumer-aspirator electric medical AccuvacRescue;
4. Pump infusion syringe “PerfusorSpace”;
5. Volumetric infusion pumps “InfusomatSpace”;
6. Heat-insulating container with automatic maintenance of the temperature of infusion solutions KST- “Omnimed”, in the version of KST-6-“Omnimed”;
7. Medical products for immobilization of patients, vacuum mattress “Nexus”, with a pump;
8. Lung ventilation apparatus LTV, version: LTV 1200;
9. Volumetric infusion pumps “InfusomatfmS”;

The device of artificial ventilation of lungs portable “MEDUMAT TRANSPORT”;

2.5. Centering of the masses of the equipped fuselage with medical equipment

Centering sheet of the masses of the equipped fuselage with medical equipment.

№	Name of object	Mass m_i		The coordinate center mass x_i, m	Static moment of mass m_i,x_i, kgm
		Relative	Absolute		
GLIDER					
1.	Fuselage (construction)	0.16579	5483.67	12.77	70010.23
2.	Horizontal plumage	0.02515	831.86	26.07	21689.37
3.	Vertical plumage	0.02907	961.52	26.07	25069.98

EQUIPMENT AND MANAGEMENT					
4.	High-altitude equipment	0.00537	177.62	12.24	2173.17
5.	Frost protection system (30%)	0.003759	124.33	12.77	1587.36
6.	Passenger equipment	0.001	33.08	2.66	87.98
7.	Decorative cladding	0.0091	300.99	13.03	3922.83
8.	Cargo equipment	0.0103	340.68	13.30	4530.74

9.	Hydraulic system (30%)	0.00693	229.22	13.30	3048.35
10.	Electrical equipment (90%)	0.0198	654.90	10.64	6967.66
11.	Location equipment	0.006	198.46	2.13	422.28
12.	Navigation equipment	0.009	297.68	1.33	395.89
13.	Radio communication equipment	0.0045	148.84	1.33	197.94
14.	Instrument equipment	0.0105	347.30	1.06	369.50
15.	Aircraft control systems (70%)	0.00644	213.01	13.30	2832.81
16.	Auxiliary power plant	0.0054376	179.85	8.73	1570.72
Empty fuselage			10523.02	13.77	144876.83
EQUIPMENT					
17.	Crew		285.00	2.66	758.04
18.	Flight attendants		75.00	2.66	199.49
19.	Documentation and tools	0.003	99.23	1.86	184.75

20.	Water (chemical gen.)		8.00	12.77	102.14
21.	Additional equipment	0	0.00	10.64	0.00
Empty equipped fuselage			10990.24	13.30	146121.24
22.	Front chassis support	0.009122	301.72	4.00	147328.12
Total			11297.96	13.05	147328.12
MEDICAL EQUIPMENT LOADING					
23.	Module 1	0.0115	115	6.875	790,625
24.	Module 2	0.0115	115	7.875	905, 625
25.	Module 3	0.0115	115	9.25	1063,75
26.	Module 4	0.0115	115	10.65	1224,75
27.	Module 5	0.0115	115	11.375	1308,125
28.	Module 6	0.0115	115	13.375	1538,125
Total			690	9,9	6 831

Table 8

Conclusion to the special part

During the special analytical part of the aircraft design, the following was determined:

- Considered the development of medical aviation and special medical evacuation by air, as well as their prospects.
- The importance of air ambulance and special medical evacuation by air is assessed.
- The requirements for air ambulance have been written out.
- Considered a mobile medical module MM-148.9520.000.
- The design features and characteristics of the medical module are described.
- Calculation for the alignment was carried out when the aircraft was assembled with six medical modules on board, where it showed that the statistical load was in the range of permissible alignment.

General conclusion

In the course of this analytical study of the projected aircraft, the following results were achieved:

- Preliminary design of a short-haul short takeoff and landing cargo aircraft.
- The layout of a short-haul cargo aircraft with a short take-off and landing.
- Position of the center of gravity for different loads.
- Calculation of the main geometrical parameters of the air carriage.
- Considered the basic principles and prospects for the development of specialized domestic medical aviation.
- A modern medical module was presented, specially selected for the design features and limitations of the aircraft being designed.
- The design features and requirements for the used medical equipment and medical aviation, in general, are described.
- MEDEVAC aircraft layout;
- Sanitary rack design;
- Design of a medical container;
- The chosen design of the high-winged aircraft with two engines located on the wing makes it possible to increase the aerodynamic characteristics of the wing. A thorough inspection and analysis of this aircraft can be concluded that this aircraft has a high quality design and reliability.

Department of Aircraft Design				**NAU 21 09 H 00 00 09 EN**			
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- This cargo plane transports cargoes up to 10 tons over short distances up to 1100 km. Distance and weight are ideal for large companies transporting cargo to airport cargo hubs and transporting them in smaller cities on such short-range aircraft.
- This design of the projected short-haul ambulance aircraft has good aerodynamic, economical indicative parameters that can help save many lives in the future.

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