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 пасажирського середньомагістрального літака пасажиромісткістю до 150 осіб **»**

Виконав: ___________**Севілья Хуан**

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

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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 the long-range passenger aircraft with 150 passenger capacity **»**

Performed by: ____ **Sevilla Juan P**

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"

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Head of Department
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_________S.R. Ignatovych
«___»________2021р

TASK

for bachelor diploma work

Juan Pablo Sevilla

1. Theme: «Preliminary design of the long-range passenger aircraft with 150 passenger capacity» Confirmed by Rector's order from 21.05.2021 year No 815/ст.
2. Period of work execution: from 24.05.2021 year to 20.06.2021 year.
3. Initial data of project: cruise speed V_{cr}= 871 km/h, flight range L = 8000 km, operating altitude H_{op} = 11 km.
4. Explanation note contains : introduction; course project part: analysis of prototypes and brief description of designing aircraft, selection of initial data; calculation part: wing geometry calculation and aircraft layout, landing gear design, engine selection, center of gravity calculation, special part: introduction and calculation of the passenger seat.
5. List of the graphical materials: layout of the airplane (A1×1); general view of the airplane (A1×1).

6. Calendar Plan

Task	Execution period	Signature
Task receiving, processing of statistical data.	25.05.2021 –27.05.2021	
Aircraft take-off mass determination.	28.05.2021 –29.05.2021	
Aircraft centering determination.	28.05.2021 –29.05.2021	
Graphical design of the aircraft and its layout.	30.05.2021 –03.06.2021	
Procedure for Passenger seat design and calculations	01.06.2021–04.06.2021	
Completion of the explanation note.	04.06.2021 –9.06.2021	
Preliminary defense	9.06.2021	

7. Task issuance date: 25.05.2021

Supervisor of diploma work ___________V.I. Zakiev

Task for execution is given for ___________Sevilla Juan P.

ABSTRACT

The diploma work « Preliminary design of the middle range passenger craft for 150 passengers » include:

46 sheets, 2 figures, 7 tables, 11 references, and 3 drawings.

Object of the design is to development of passenger aircraft with the possibility to accmodate 150 passengers.

Aim of the diploma work is the development of the aircraft preliminary design for an airplane and estimate its characteristics.

The design methodology is based on prototype analysis and the selection of the most advanced technical judgements.

The diploma work contains drawings of the middle range aircraft with 150 passengers, calculations and drawing of the aircraft layout, determination of elevators attachments.

AIRCRAFT, PRELIMININARY DESIGN, CENTER OF GRAVITY POSITION, ELEVATORS ATTACHMENTS.

Format	№	Designation	Name	Quantity	Notes
			<u>General documents</u>		
A4	1	NAU 21 05W TT	Task of work	1	
			Graphic documentation	2	
A1		NAU 21 05W 00 00 00 11 GV	Passenger middle range aircraft	2	
A1	2	NAU 21 05W 00 00 00 11 GV	General view	54	
		NAU 21 05W 00 00 00 11 AL	Aircraft layout	1	
A1	4	NAU 21 05W 25 50 00 11 PS	<u>Passenger middle range aircraft</u>		
			Shock absorber design	1	

					NAU 21 05W 00 00 00 11 EN			
Ch.	Sheet	Doc.№	Sign.	Date				
Performed by	Sevilla Juan P.				List of diploma work	List	Sheet	Sheets
Supervisor	V.I. Zakiev.							
Adviser						AF 402 134		
Stand. contr.	Khyzhnyak S.							
Head. of dep.	Ignatovych S.							

CONTENT

Department of Aircraft Design				NAU 21 05W 00 00 00 11 EN			
Performed by	Sevilla Juan P			Content	List	Sheet	Sheets
Supervisor	V.I. Zakiev.						
Adviser					AF 402 134		
Stand. contr.	Khizhnyak S.V.						
Head of Dep.	Ignatovych S.R.						

Introduction

Lately, we can clearly observe the increase in the volume of passenger quantity, especially in local airlines as well as in international ones, which increased dramatically the need for passenger traffic.

To avoid money with a low freight amount, transportation plans were needed for distances that are not great.

To ensure profitable operation of aviation technology with high reliability and regularity of flights in the highly competitive market need for a new aircraft in civil aviation that knlws the requirements of the international organization of air transport, and in particular:

-Flight safety;

- Increasing comfort operation;
- Reduce the noise of the engine;
- Reducing emissions of gases.

The plane projected must also satisfy the following requirements:

- Comfortable passenger compartment follows the highest requirements;
- To perform takeoff and landing on unequipped unpaved runways;
- Operation in a wide temperature range and elevation airfields;
- Reliability and ease of operation;
- Optimal ratio of cost, efficiency and comfort;

The purpose of this diploma project is to create an aircraft intended for the carriage of 150 passengers and baggage on middle distance routes.

1. PROJECCT PART

1.1. Calculation of the geometrical parameters for the main parts of the aircraft

The layout of the aircraft consists of composing the relative of its parts and constructions, including all types of cargo (passengers, luggage, cargo, fuel, etc.).

The choice of the scheme of the composition and parameters of the aircraft is directed by the best operating operator.

Wing geometry calculation

Geometrical characteristics of the wing are determined from the take of weight m_0 and specific wing load P_0.

Wing area is: $S_w = \frac{m_o \cdot g}{P_o} = \frac{74300 \cdot 9,81}{4.871 \cdot 1000} = 149.6\ m^2$

Wing span is: $l = \sqrt{S \cdot \lambda} = 38.29\ \ (m)$

Root chord is: $b_o = \frac{2S_w \cdot \eta_w}{(1+\eta_w) \cdot l} = 5.831\ \ (m)$

Tip chord is: $b_t = \frac{b_o}{\eta_w} = 1.983\ \ (m)$

Maximum wing width is determined in the forehead i-section and by its span it is equal: $c_i = c_w \cdot b_t = 0,12 \cdot 1,983 = 0,238\ \ (m)$

On board chord for trapezoidal shaped wing is:

$$b_{ob} = b_0 \cdot (1 - \frac{(\eta_w - 1) \cdot D_f}{\eta_w \cdot l_w}) = 5,831 \cdot (1 - \frac{(2,94-1) \cdot 4,11}{2,94 \cdot 38,29}) = 5,418\ \ (m)$$

At the choice of the wing power scheme, we can define the number of spars and their position, the wing division places.

longeron wing is common to the light sport, sanitary and personal aircrafts.

Relative disposition of the longerons by chord is equal: $\bar{x}_i = \frac{x_i}{b}$, where x_i – distance of i-longeron to the tip of the wing, b – chord.

Wing with two longerons: x_1=0.2b_i; x_2=0.6b_i;

I use the geometrical method of mean aerodynamic chord determining, it has been presented in the appendix. Mean aerodynamic chord is equal: $b_{MAC} = 4,2\ m$

After determining the geometric characteristics of the wing, we thought about the geometry of the ailerons and high lift.

Ailerons geometrical parameters are determined in next consequence:

Ailerons span: $l_{ai} = 0,375 \cdot \frac{l_w}{2} = 0,375 \cdot \frac{38,29}{2} = 7,17\ (m)$

Ailerons chord determine using the formula:

It is not necessary to increase the lail and bail more than the recommended values. With the increase of lail more than the given value, the increase of the aileron coefficient decreases and the span of the high lift devices decreases.

On generation aircraft there is a relative decrease in the wingspan and the area of the ailerons. So, lail = 0.122. In this case for the transverse control of the plane we use spoilers together with the ailerons. Due to this, the range and area of high lift devices can be increased, which improves the takeoff and landing of the aircraft.

Aerodynamic compensation of the aileron.

Axial $S_{axinail} \leq (0.25…0.28)\ S_{ail} = 0,26 \cdot 4,862 = 1,264\ (m^2)$

Inner axial compensation $S_{inaxinail} = (0.3..0.31)\ S_{ail}$;

Area of ailerons trim tab.

For two engine airplane: $S_{tail} = 0,04...0,06 \cdot S_{ail} = 0,05 \cdot 4,862 = 0,2431\ (m^2)$

Range of aileron deflection

Upward $\delta'_{ail} \geq 25°$;

Downward $\delta''_{ail} \geq 15°$.

Determination of the geometric parameters of the wing's high-lift devices. The objective of this chapter is to give the takeoff and landing coefficients of the wing lift force, assumed in the above calculations with the selected rate of the high lift devices and the type of airfoil.

Antes de realizar los cálculos, es necesario tomar el tipo de perfil aerodinámico debido al catálogo de perfil aerodinámico, especificar el valor del coeficiente de sustentación Cymaxbw y determinar

necessary increase for this coefficient $\overline{C}_{y\max}$ for the high-lift devices outlet by the formula: $\Delta\overline{C}_{y\max} = (C_{y\max l} / C_{y\max bw})$

Where cymaxl is the coefficient necessary for the lifting force with the wing landing configuration to guarantee the landing of the aircraft

In the modern design the rate of the relative chords of wing high-lift devices is:

b_{sf} = 0.25..0.3 – for the split edge flaps;

b_f = 0.28..0.3 – one slotted and two slotted flaps;

b_f = 0.3..0.4 – for three slotted flaps and Faylers flaps;

b_s = 0.1..0.15 – slats.

Effectiveness of high-lift devices (C^*_{ymaxl}) rises proportionally to the wing span increase, serviced by high-lift devices, so we need to obtain the biggest span of high lift devices ($l_{hld} = l_w - D_f - 2l_{ail} - l_n$) due to use of flight spoiler and maximum diminishing of the are of engine and landing gear nacelles.

During the choice of structurally-power schemes, hinge-fitting schemes and kinematics of the high-lift devices we need to come from the statistics and experience of domestic and foreign aircraft construction. We need to mention that in the majority of existing constructions elements of high-lift devices are done by longeron structurally-power schemes.

Fuselage layout

when choosing the shape and size of the fuselage section we have to come from the aerodynamic requirements (aerodynamics and transverse).

Aplicable a pasajeros subsónicos y aeronaves (V <800 km / h) la resistencia a las olas no lo afecta. Entonces, para elegir entre las condiciones de la lista, los valores de resistencia a la fricción Cxf y resistencia del perfil Cxp.

During the transonic and subsonic flights, shape of fuselage nose part affects the value of wav resistance C_{xw}. Application of oval shape of fuselage nose part significantly diminishing its wave resistance.

During the transonic and subsonic flights, shape of fuselage nose part affects the value of wav resistance C_{xw}. Application of oval shape of fuselage nose part significantly diminishing its wave resistance.

For transonic airplanes fuselage nose part has to be:

$$l_{nfp} = 2,5 \cdot D_f = 2,5 \cdot 4,11 = 10,275 \ (m)$$

Except aerodynamic requirements consideration during the choice of cross section shape, we need to consider the strength and layout requirements.

To determine a specific weight, the most convenient shape of the fuselage cross section is the round cross section. if applicable, the minimum width of the fuselage skin. With a partial case, we can use the combination of two or more series of vertical or horizontal circles.

For cargo aircraft, the aerodynamics is not that complicated to choose the shape of the fuselage, and also the cross-sectional shape can be rectangular.

we call attention to the geometric parameters: fuselage diameter Df; fuselage length lf; aspect ratio of the fuselage; aspect ratio of the nose part of the fuselage; aspect ratio of the tail unit. The fuselage length is defined taking the aircraft design, layout and peculiarities of the position of the aircraft's center of gravity with the conditions of the attack landing angle α and the belay.

Fuselage length is equal: $l_f = \lambda_f \cdot D_f = 8,5 \cdot 4,11 = 34,9 \ (m)$

Fuselage nose part aspect ratio is equal: $\lambda_{fnp} = \frac{l_{fnp}}{D_f} = \frac{10,275}{4,11} = 2,5$

Fuselage rear part aspect ratio is equal: $\lambda_{frp} = \lambda_f - \lambda_{fnp} = 8,5 - 2,5 = 6$

Length of the fuselage rear part is equal: $l_{frp} = \lambda_{frp} \cdot D_f = 6 \cdot 4,11 = 24,66\ (m)$

During the determination of fuselage length we seek for approaching minimum mid-section S_{ms} from one side and layout demands from the other.

For passenger and cargo airplanes fuselage mid-section first of all comes from the size of passenger saloon or cargo cabin. One of the main parameter, determining the mid-section of passenger airplane is the height of the passenger saloon.

For short range airplanes we may take the height as: h_1=1.75m; passage width b_p=0.45...0.5m; the distance from the window to the flour h_2=1m; luggage space h_3=0.6...0.9m.

For long range airplanes correspondingly: the height as: h_1=1.9m; passage width b_p=0.6m; the distance from the window to the flour h_2=1m; luggage space h_3=0.9...1.3m.

I choose the next parameters:

Cabin height: h_1=2m

Window to floor distance: h_2=1m

Desde el punto de vista del diseño conviene tener una sección transversal redonda, ya que en este caso será la más resistente y ligera. Para pasajeros y carga, pero no siempre es lo más conveniente. En la mayoría de los casos, una de las formas más adecuadas es utilizar la combinación de la intersección de dos círculos o la forma ovalada del fuselaje. Podemos recordar que la forma ovalada no es correcta en la producción ya que los paneles superior e inferior se combarán debido a la presión adicional y requerirán vigas de sentina adicionales y otras extensiones de construcción.

Step of normal bulkhead in the fuselage construction is in the range of 360...500mm, depends on the fuselage type and class of passenger saloon.

Form the design consideration with the diameter less than 2800mm we don't use such shape and we follow to the intersecting circles cross section. In this case the flour of the passenger saloon is done in the plane of are closing.

The windows are located in a row of light. The shape of the window is oval, with a diameter of 300 ... 400 mm, or rectangular with oval corners.

The window step corresponds to bulkhead step and is 500...510mm.

For economic salon with the scheme of allocation of seats in the one row (2 + 2) determine the appropriate width of the cabin

$$B_{cabin} = n_s \cdot b_{seat} + (n_s + 2) \cdot b_{arm} + b_{aisle} = 6 \cdot 0,5 + 8 \cdot 0,051 + 0,5 = 3.908 \ (m)$$

n_s- number of seat in one row

b_{seat} = 0,5m

b_{arm}= 0,051m

b_{aisle}=0,5m

The length of passanger cabin is equal:

$$l_{cab} = 1200 + (\frac{n}{m} - 1) \cdot t_{st} + (235...250) mm$$

Where

n - is number of passanger

t – step between seats

$$l_{cab1} = 1300 + (4-1) \times 960 + 250 = 4,430 \ (m)$$

- for bussines class

$$l_{cab2} = 1300 + (23-1) \times 810 + 250 = 19,370 \ (m)$$

- for economic class

The total length of the passenger compartment excluding buffets, toilets and coat is L = 19,370+4,430=23,8 (m)

Cabin volume is equal:

$$V_{cab} = l_{cab} \cdot \frac{\pi \cdot (D_f - 0,24m)^2}{4} = 23,8 \cdot \frac{3,14 \cdot (4,11 - 0,24)^2}{4} = 279,81 \ (m^3)$$

Volume for one passenger is equal:

$$V_{pas} = 1,2 \cdot \frac{V_{cab}}{n} = 1,2 \cdot \frac{279,81}{150} = 2,24 \ (m^3)$$

Luggage compartment

Given the fact that the unit of load on floor K = 400… 600 kg/m^2

The area of cargo compartment is defined:

$$S_{cargo} = \frac{m_c}{0,4 \cdot K} + \frac{m_l}{0,6 \cdot K} = \frac{2250}{0,4 \cdot 400} + \frac{180}{0,6 \cdot 400} = 14,81\ (m^2)$$

Where, m_c and m_l the mass of cargo mail and luggage

Cargo compartment volume is equal:

$$V_c = \overline{V}_c \cdot n_{pas} = 0,17 \cdot 150 = 25,5\ (m^3)$$

Luggage compartment design similar to the prototype

Kitchen and buffets

International rules say that if the plane has a mixed layout, be sure to prepare two dishes. If the flight time is less than 3 hours at this time from the meal to the passengers, in this case there are no cabinets for water and tea. Tickets cannot be made to flight time with buffets and bathrooms of less than one hour. The kitchen cabinets and should preferably be placed between the cabin and the passenger. Refreshments and food are forbidden to be placed near the bathrooms. The total amount of food Vc = (0.1 ... 0.12) -n_{pass} and its area:

$$S_к = \frac{V_к \cdot n_{pass}}{h_к}$$ where, h_k – height of buffets

$$S_к = \frac{0,12 \times 150}{1,8} = 10\ (m^3)$$

Number of meals per passenger breakfast, lunch and dinner – 0,8 kg; tea and water – 0,4 kg;

If food organized once it is given a set number 1 weighing 0,62 kg. Food passangers appers every 3.5…4 hour flight.

Buffet design similar to prototype.

Coats: Coat room area:

$$S_{coat} = (0,035..0,04) m^2 \cdot n_{pass} = 6\ (m^2)$$

Coat design similar to prototype.

Toilets:

Number of toilet facilities is determined by the number of passengers and flight duration: with t> 4:00 one toilet for 40 passengers, at t = 2 ... 4 hours and 50 passengers t <2 hours to 60 passengers.

At the time of the flight is less than 1 hour and number of passengers to 15,

the toilets do not. With a large number of toilets for increased throughput ability toilet separated from the sink. A toilet area Stual = 1,5 ... 1,6 m2 with a width of not less than one meter. Standards have provided water supply and toilets chemical substances per person, for t> 4:00 q = 2,0 kg, t = 2 ... 4:00 q = 1,0 kg,

t <2:00 q = 0,7 kg . The total stock of water and chemiacal substances:

$m = q \cdot n_{pass} = 1 \cdot 150 = 150 \ (kg)$ Toilets design similar to the prototype.

Layout and calculation of basic parameters of tail unit

One of the most significant duties of aerodynamic design is choosing the location of the tail unit. To ensure longitudinal stability overload, its center of gravity must be located in front of the focus of the aircraft, the distance between these points is related to the mean value of the aerodynamic chord of the wing, defines the longitudinal stability rate.

$$m_x^{Cy} = \bar{x}_T - \bar{x}_F < 0$$

Where m^{Cy}_x –is the moment coefficient; $\bar{x}_T, \bar{x}_F$ - center of gravity and focus coordinates. If m^{Cy}_x=0, than the plane has the neutral longitudinal static stability, if m^{Cy}_x>0, than the plane is statically instable. In the normal aircraft scheme (tail unit is behind the wing), focus of the combination wing – fuselage during the install of the tail unit of moved back.

Range of static moment coefficient: horizontal Ahtu, vertical Avtu given in the table above with typical arm correlations Htu and Vtu. Using the table we will find the first approach to determining geometric parameters.

Determination of the tail unit geometrical parameters

Area of vertical tail unit is equal:

$$S_{vtu} = A_{vtu} = \frac{l_w \cdot S_w}{L_{vtu}} = 0,1 \cdot \frac{38,29 \cdot 149,6}{6,99} = 81,9 \ (m^2)$$

Area o horizontal tail unit is equal:

$$S_{htu} = A_{htu} \cdot \frac{b_{mac} \cdot S_w}{L_{htu}} = 0,75 \cdot \frac{4,2 \cdot 149,6}{6,99} = 67,42 \ (m^2)$$

Values L_{htu} and L_{vtu} depend on some factors. First of all their value are influenced by: the length of he nose part and tail part of the fuselage, sweptback and wing location, and also from the conditions of stability and control of the airplane.

In the first approach we may count that $L_{htu} \approx L_{vtu}$ and we may find it from the dependences:

Trapezoidal scheme, normal scheme L_{htu}=(0.2...3.5)b_{CAX}

Length of vertical TU is equal: $l_{vtu} = 0,2 \cdot l_w = 0,2 \cdot 38,29 = 7,658 \ (m)$

Length of horizontal TU is equal: $l_{htu} = 0,4 \cdot l_w = 0,4 \cdot 38,29 = 15,316 \ (m)$

Determination of the elevator area and direction:

Altitude elevator area: $S_{elv} = 0,325 \cdot S_{htu} = 0,35 \cdot 67,42 = 23,597 \ (m^2)$

Rudder area: $S_{rud} = 0,4 \cdot S_{vtu} = 0,4 \cdot 81,9 = 32,76 \ (m^2)$

Choose the area of aerodynamic balance.

0.3≤M≤0.6

S_{eb}=(0.22..0.25)S_{ea}

S_{rb}=(0.2..0.22)S_{rd}

Elevator balance area is equal:

$$S_{eb} = 0,22 \cdot 23,597 = 5,191 \ (m^2)$$

Rudder balance area is equal:

$$S_{rb} = 0,22 \cdot 32,76 = 7,21 \ (m^2)$$

To prevent over balance of the control surface we need to consider:

$$\frac{S_{eb}}{S_{el}} = \frac{S_{rb}}{S_{rd}} \le 0,3 \qquad \frac{S_{eb}}{S_{el}} = \frac{5,191}{23,597} = 0,22 \qquad \frac{S_{rb}}{S_{rud}} = \frac{7,21}{32,76} = 0,22$$

The area of altitude elevator trim tab:

$$S_{te} = 0,1 \cdot S_{elv} = 0,1 \cdot 23,597 = 2,36 \ (m^2)$$

and for rudder of the aircraft with two engines S_{ttea}=(0.04..0.06)$S_{ea,}$ for the aircraft with two engines: $S_{tr} = 0,05 \cdot S_{rud} = 0,05 \cdot 32,76 = 1,638 \ (m^2)$

Tail unit span is related to the following dependence:

$$l_{htu} = 0,4 \cdot l_w = 0,4 \cdot 38,29 = 15,316 \ (m)$$

In this unit, the lower limit refers to the aircraft with a turbojet engine, which comes with stabilization at all times of movement.

The height of the vertical tail unit h_{bo} is determined accordingly to the location of the engines. Taking it into account we assume:

- Low wing, EonW, M<1 h_{vtu}=(0.14..0.2)l_w;
- Engine in the root part of the wing h_{vtu}=(0.13..0.165)l_w
- Engine in the tail part h_{vtu}=(0.13..0.14)l_w

Height of the vertical tail unit is equal:

$$l_{vtu} = 0,2 \cdot l_w = 0,17 \cdot 38,29 = 6,99 \ (m)$$

For high wing airplanes we need to set the upper limit.

Tapper ratio of horizontal and vertical tail unit we need to choose:

- For planes M<1 η_{htu}=2...3 η_{vtu}=1…3.3

Tail unit aspect ratio

We may recommend:

- For transonic planes λ_{vtu}=0.8..1.5 Λ_{htu}=3.5...4.5

Determination of tail unit chords b_{end}, b_{MAC}, b_{root}:

Horizontal tail unit tip chord:

$$b_{tchtu} = \frac{2 \cdot S_{htu}}{(\eta_{htu}+1) \cdot l_{htu}} = \frac{2 \cdot 67,42}{(2,5+1) \cdot 15,316} = 2,515 \ (m)$$

Vertical tail unit tip chord:

$$b_{tcvtu} = \frac{2 \cdot S_{vtu}}{(\eta_{vtu}+1) \cdot l_{vtu}} = \frac{2 \cdot 81,9}{(1,5+1) \cdot 7,658} = 8,556 (m)$$

Horizontal tail unit root chord:

$$b_{rchtu} = b_{rchtu} \cdot \eta_{htu} = 2,515 \cdot 2,5 = 6,29 \ (m)$$

Vertical tail unit root chord:

$$b_{rcvtu} = b_{rcvtu} \cdot \eta_{vtu} = 8,556 \cdot 1,5 = 12,834 \ (m)$$

Horizontal tail unit mean aerodynamic chord:

$$b_{MAChtu} = 0,66 \cdot \frac{\eta_{htu}{}^2 + \eta_{htu} + 1}{\eta_{htu} + 1} \cdot b_{tchtu} = 0,66 \cdot \frac{2,5^2 + 2,5 + 1}{2,5 + 1} \cdot 2,515 = 4,62 \ (m)$$

Vertical tail unit mean aerodynamic chord:

$$b_{MACvtu} = 0,66 \cdot \frac{\eta_{vtu}{}^2 + \eta_{vtu} + 1}{\eta_{vtu} + 1} \cdot b_{tcvtu} = 0,66 \cdot \frac{1,5^2 + 1,5 + 1}{1,5 + 1} \cdot 8,556 = 10,73 \ (m)$$

For horizontal and vertical tail unit in the first approach, $\overline{C}_{TU} \approx 0.8\overline{C}_w$.

For more accurate: Subsonic $\overline{C}_{TU}$ =0.08..0.10

the fixation of the stabilizations is fin, we must use the upper limit of Ctu, to give a base of fixation in the fin.

Tail unit sweptback is not more than wing sweptback. We do it to provide the control of the airplane in shock stall on the wing.

Landing gear design

In the first design phase, with the position of the aircraft's center of gravity but without an overview drawing of the aircraft, only the part of the landing gear parameters can be determined.

Main wheel axel offset is: $e_g = 0,175 \cdot b_{MAC} = 0,175 \cdot 4,2 = 0,735 \ (m)$

With the large wheel axial offset the lift-of of the front gear during take of is complicated, and with small, the drop of the airplane on the tail is possible, when the loading of the back of the airplane comes first. Landing gear wheel base comes from the expression:

$$B_g = 0,454 \cdot l_f = 0,4 \cdot 34,9 = 13,96 \ (m)$$

Large value belongs to the airplane with the engine on the wing (EonW).

The last equation means that the nose support carries 6...10% of aircraft weight.

Front wheel axial offset will be equal:

$$d_{ng} = B_g - e_g = 13,96 - 0,735 = 13,225(m)$$

Wheel track is: $K_{wt} = 0,35 \cdot B_g = 0,35 \cdot 13,96 = 4,886 \ (m)$

On a condition of the prevention of the side nose-over the value K should be > 2H, where H – is the distance from runway to the center of gravity.

Wheels for the landing gear is chosen by the size and run loading on it from the take off weight; for the front support we consider dynamic loading also.

Type of the pneumatics (balloon, half balloon, arched) and the pressure in it is determined by the runway surface, which should be used. We install breaks on the main wheel, and sometimes for the front wheel also.

The load on the wheel is determined:

K_g = 1.5...2.0 – dynamics coefficient.

Nose wheel load is equal:

$$P_{n\lg} = \frac{e_g \cdot m_0 \cdot g \cdot K_g}{B_g \cdot z_{n\lg}} = \frac{0,735 \cdot 74300 \cdot 9,8 \cdot 1,75}{13,96 \cdot 2} = 33544,77 \ (N)$$

Main wheel load is equal:

$$P_{m\lg} = \frac{(B_g - e_g) \cdot m_0 \cdot g}{B_g \cdot z_{m\lg} \cdot n_{m\lg}} = \frac{(13,96 - 0,735) \cdot 9,8 \cdot 74300}{13,96 \cdot 4 \cdot 2} = 86225,38 \ (N)$$

By calculated P_{main} and P_{nose} and the value of $V_{take\ off}$ and $V_{landing,}$ pneumatics is chosen from the catalog, the following correlations should correspond.

$$P^K_{slmain} \geq P_{main}; P^K_{s\ln ose} \geq P_{nose}; V^K_{landing} \geq V_{landing}; V^K_{takeoff} \geq V_{takeoff}$$

Table 2.6

Aviation tires for designing aircraft.

Main gear		Nose gear	
Tire size	Ply rating	Tire size	Ply rating
H34x9.25-18	18	22x8.0-10	12

Choice and description of turbofan engines type, CFM 56-3*:*

The CFM International CFM56 is a set of high-bypass turbofan aircraft engines manufactured by CFM International (CFMI), with a thrust of 18,500 to 34,000 pound-force.

CFMI is a 50% joint venture of Safran Aircraft Engines (, France, and GE Aviation (GE), United States..

Examples of application CFM 56-3 of turbofan, by-pass engine type

Model	Thrust	Bypass ratio	Dry weight	Applications
CFM56-3B-1	20,000 lbf (89 kN)	6.0	4,276 lb (1,940 kg)	Boeing 737-300, Boeing 737-500
CFM56-3B-2	22,000 lbf (98 kN)	5.9	4,301 lb (1,950 kg)	Boeing 737-300
CFM56-3C-1	23,500 lbf (100 kN)	6.0	4,301 lb (1,950 kg)	Boeing 737-400, Boeing 737-500

1.2 Determination of the aircraft center of gravity position

Define of the mass power of the equipped selage

The mass of the equipped wing has the mass of its frame, the mass of the equipment placed on the wing and the mass of the fuel. Regardless of mounting location (to the wing or the fuselage), the main landing gear and the nose gear are inside the wing mass register. The mass register includes the names of the objects, the mass, the coordinates of their center of gravity. The origin of the given coordinates of the centers of mass is chosen by projecting the nose point of the mean aerodynamic chord (MAC) to the XOY surface.

The example list of the mass objects for the aircraft, where the engines are located under the wing, included the names given in the table 2.2.

№	Object	Mass $m_i^{/}$		C.G. coordinates	Mass moments
	Name	units	total	X_I, m	$m_i^{/} X_I$, kg • m
1	Wing (structure)	0.11101	8248,043	1.806	14895.965
2	Control system, 30%	0.00189	140.427	2,52	353,876
3	Electrical equipment, 30%	0.00978	726,654	0.42	305.194
4	Anti-ice system, 70%	0,01582	1175,426	0,42	493,67892
5	Power plant	0,08837	6565,891	-1,5	-9848,8365
6	Hydraulic systems, 70%	0,01211	899,773	2,52	2267,42796
7	Equiped wing	0,23898	17756,214	1,087631596	8467,306758
8	Nose landing gear	0,0093975	698,23425	-10	-6982,3425
9	Main landing gear	0,0281925	2094,70275	2,3	4817,816325
10	Fuel	0,30065	22338,295	1,806	40342,96077
	Total	0,57722	42887,446	1,087631596	46645,74135

Determine the coordinates of the center of gravity of the loaded wing:

$$X'_K = \frac{\sum m'_i \cdot X'_i}{\sum m'_i};$$

Determination of the mass power of the equipped fuselage

Origin of the coordinates is chosen in the projection of the nose of the fuselage on the horizontal axis. For the axis X the construction part of the fuselage is given. The example list of the objects for the aircraft, which engines are mounted to the fuselage, is given in table 2.3.

The centre of gravity (C.G.) coordinates of the fully equipped fuselage are determined by formulas:

$$X_f = \frac{\Sigma m_i^/ X_i^/}{\Sigma m_i^/};$$

$$Y_f = \frac{\Sigma m_i^/ Y_i^/}{\Sigma m_i^/}$$

After we determined the C.G. of fully equipped wing and fuselage, we construct the moment equilibrium equation relatively fuselage nose:

$$m_f x_f + m_w (x_{MAC} + x_w^/) = m_0 (x_{MAC} + C)$$

From here we determined the wing MAC leading edge position relative to fuselage, means $\mathbf{X_{mac}}$ value by formula:

$$x_{cax} := \frac{m_f \cdot X_f + m_w \cdot X_w - m_0 \cdot C_n}{m_0 - m_w} \rightarrow \frac{28732.88789 \cdot kg \cdot 20.556 \cdot m + 45425.112 \cdot kg \cdot 1.077 \cdot m - 74158 \cdot kg \cdot 0.935676 \cdot m}{74158 \cdot kg - 45425.112 \cdot kg} = 19.844 m$$

where m_0 – aircraft takeoff mass, kg; m_f – mass of fully equipped fuselage, kg; m_w – mass of fully equipped wing, kg; C – distance from MAC leading edge to the C.G. point, determined by the designer C = (0,22...0,25) B_{MAC} = 0,23x2,95=0,678 for the low wing aircraft.

Knowing the wings position relatively to fuselage on the layout drawing, we connect the wings power elements and the fuselage. After the wings and fuselage arrangement a C.G. calculation takes place. C.G. positioning is called the relative position of centre of masses relatively to MAC leading edge.

Determination of the mass power of the equipped fuselage:

Origin of the coordinates is chosen in the projection of the nose of the fuselage on the horizontal axis. For the axis X the construction part of the fuselage is given. We make centering of the fuselage, which is shown at the table 2.3.

Table 1.3.

Trim sheet of equipped fuselage masses

№	Objects	Mass $m_i^{/}$		C.G. coordinates	Moment of mass
	Name	units	total	X_I, *m*	$m_i^{/} X_I$, $kg \cdot m$
1	**2**	**3**	**4**	**5**	**6**
1	Fuselage	0,07673	5701,039	16	91216,624
2	Horizontal stabilizer	0,00884	656,812	32	21017,984
3	Vertical stabilizer	0,00873	648,639	31	20107,809
4	Radar	0,0010601	78,76543	1	78,76543
5	Radar equipment	0,0032	237,76	2	475,52
6	Instrument panel	0,00134	99,562	3	298,686
7	Air-navigation euipment	0,0048	350,64	2	713,28
8	Toilet	0,000538	39,9734	25	999,335
9	Coat room	0,0022	163,46	7	1144,22
10	AC Control system, 70%	0,00441	327,663	17	5570,271
11	Hydraulic system, 30%	0,00519	385,617	14	5398,638
12	Electrical equipment, 70%	0,02282	1695,526	15	25432,89

13	Buffet	0,00067	50	4	200
14	Radio equipment	0,0024	178,32	3	534,96
Continuation of the table 1.3					
15	Anti ice system , 30 %	0,00678	503,754	2	1007,508
16	Rescue equipment	0,0002202	16,36086	17	278,13462
17	Auxilary power unit	0,002069	153,7267	30	4611,801
18	Heat insulation-sound proofing	0,00365	271,195	17	4610,315
19	Chemical liquids	0,002155	160,1165	30	4803,495
20	Water	0,001009	74,9687	30	2249,061
21	Oxygen equipment	0,00269	199,867	17	3397,739
22	Custom equipment	0,0028202	209,5408 6	5	1047,7043
23	Crew seats	0,000672	49,9296	2	99,8592
24	Equipped fuselage without payload	0,2494425	18533,79	14,56920	270022,701
25	Passengers	0,1433001	10647,19	15	159707,961
26	Foodstuff	0,00162	120,366	4	481,464
27	Baggage	0,000336	24,9648	9	224,6832
28	Cargo, mail	0,0185696	1379,725	15	20695,8771
29	Crew	0,0010094	74,99842	2	149,99684
	Total	0,42278	31412,55	14,51949	456094,408

	Total	1	74299,99		

Calculation of center of gravity positioning variants

The list of mass objects for centre of gravity variant calculation given in Table 1.4 and Center of gravity calculation options given in table 1.5, completes on the base of both previous tables.

Table

Calculation of C.G. positioning variants

Objects name	Mass, kg	C.M. coordinate X_I, m	Mass moment $m_i X_I$, $kg \cdot m$
Equipped wing (without fuel and LG)	17756,214	0,96149807	17072,56549
Nose L.G (extended)	698,23425	3	2094,70275
Main L.G (extended)	2094,70275	17,5	36657,29813
Fuel	23064,8586	1,806	41655,13463
Equiped fuselage	18533,79675	14,56920592	270022,7013
Passengers bussines class	436,141	9	3925,269
Passengers economical class	10647,1974	15	159707,9615
Food1	120,366	4	481,464
Food 2	120,366	4	481,464
Baggage	24,9648	9	224,6832
Cargo	1379,72514	20	27594,50287
Nose L.G (opened)	698,23425	4,9	3421,347825
Main L.G (opened)	2094,70275	17,6	36866,7684

Table 1.5

Airplanes C.G. position variants

№	Variants of the loading	Mass, kg	Moment of the mass, кg*m	Centre of the mass, m	Centering
1	Take off mass (LG opened)	74299,99996	560472,7351	16,5	28,787
2	Take off mass (LG retracted)	74299,99996	562008,8505	16,232	27,876
3	Landing variant (LG opened)	51961,70496	553007,9001	15,877	25,768
4	Transportation variant(without payload)	62297,80319	369593,5059	14,93	21,866
5	Parking variant (without payload, fuel)	39082,94775	325847,2677	13,485	19,765

Conclusion to the project part

In this topic we have determined the characteristics of the position of the central mass. We teach the main calculations to carry of an aircraft. We have also checked the location of the mass in the main parts of the aircraft and main equipment by its distance from the main aerodynamic chord.

After designing the wing and fuselage we performed a few calculations to determine the center of gravity of the equipped aircraft. In order to guarantee the best work.

1.1.1 Choice of the projected data

A selection of the optimal design parameters of the aircraft is the multi-dimensional optimization duty, which is intended to build an aircraft "with a promising appearance". The configuration covers the entire flight complex: technical, weight, aerodynamic and economic characteristics. In the design of the "Appearance of the airplane" the statistical methods of the first stage are used transfers, aerodynamic dependence and approximate statistics. The second stage uses a complete aerodynamic calculation; Aircraft specific formulas for aggregate weight calculations, experimental data.

Prototypes of the aircraft, projected by aircraft were in class 80-100 passengers. Such aircraft like Boeing 737-400, Boeing 737-800 and Boeing 737-300 will compete with projected aircraft in this market segment. Statistical data of planes prototypes are presented in tables 1.1.

Table 1.1

Operational - technical data of planes prototypes

PARAMETER	PLANES		
	737-400	737-800	737-300
The purpose of airplane	Passang.	Passang.	Passang.
Crew/flight attend. persons	2/2	2/2	2/2
Most pay-load, $m_{к.max}$, kg	62823	79015	56472
Passenger's seat	168	189	149

The height of the flight $V_{w.ек.}$, m	11300	12500	10700
Range $m_{к.max}$, km	5000	5765	4150
Take off distance $L_{зл.д.}$, m	2356	2241	2012
Landing distance $L_{пос.д.}$, m	1540	1630	1400
Number and type of engines	CFM56-3B2	CFM56-7B24	CFM56-3B1
Takeoff thrust (power) kN kW	2 × 10	2 x 11,0 2 x 11,9	2 × 9,1
Specific case fuel take-off, kg	20.9		25.5
The form of the cross-section fuselage	circular	circular	circular
Extension of the fuselage	9,4	11,8	8,38
Extending the nose and tail unit part	5,64	4,6	4,2
Step passenger load, m	0,762	0,81	0,81
Sweepback on 1/4 chord, ^{0}	25	24	25

The scheme is defined by the location of the aircraft units, their number and shape. The aerodynamic, operational characteristics of the aircraft depend on the design of the aircraft and the aerodynamic scheme. Fortunately, the chosen scheme allows to increase the safety and regularity of the flights as well as the monetary efficiency of the aircraft.

1.1.2 Brief description of the main parts of the aircraft

The plane is a cantilever high-wing monoplane with bypass turbojet engines placed in nacelles under the wing and tricycle landing gear with a front single-strut landing gear and two main gears

A swept wing with a high aspect ratio, which is based on new supercritical profile. The leading edge of the wing from the fuselage to the pylon concludes the deflectable edge of the wing, and then three sections of slats. At the trailing edge are fitted the Fauler's flaps. Fuselage has circular cross section. Empenage is a single-fin type, T – shaped, fixed stabilizer is mounted on the fin. Rudder and elevators are not equipped with aerodynamic balance.

1.1.3 Fuselage

The fuselage is based on metallic completer, with spar construction beams (as semi-monocoque). The foreknowledge of a relatively thick thick skin that comes with beams.

Also that it combines the advantages of shape and elongation of the pieces, it has a minimum resistance and a high critical value of the number M.

In the cabin there are seats for the first officer and second pilot. There is also a space for an additional crew member.

The first flight officer is on the left on the flight, the second officer is on the right, the additional crew member in the middle of the cockpit behind the pilots. In front of the pilots, instrument panels are installed and with them an average pilot console. The glazing of the cockpit canopy is an upper electrical panel. The port side of the fuselage has a side console for the first officer, and on the right side there is a side console for the copilot.

In front of the first and second pilot stations are steering wheels to move the elevator, ailerons and pedals to steer the rudder. Flight navigation instruments can be viewed and taught on the dashboard to monitor the proper operation of the power plant and other instruments and signaling devices.

On the left and right sides of the salons are windows, there are emergency exits on the left and right side. Along the cabin on both sides there are luggage racks for accommodate the personal belongings of passengers. In the lower part, panels with ventilation nozzles, lights, buttons to turn on the lighting, a call button for the aircraft personnel and the numbering of the seat lights are installed. The lighting panels are located in the middle part of the ceiling: there are lights for the sides and the bottom of the trunks.

Under the floor of the hermetic part of the fuselage, the following rooms and compartments are located: the chassis front landing gear (leaking), the front cargo compartment, the main landing gear compartment (leaky), the rear cargo compartment, the technical compartment. The front and rear cargo compartments are hermetic, each has a hatch on the right side and is equipped with a container locking system.

1.1.4 Wing.

The wing of the aircraft is a caisson structure without operating connectors. In such a wing, the material is most rationally used, the mass of the wing is minimal. The inner volume of the wing is more free from structural elements and a considerable amount of fuel can be placed in it to the wing of the caisson type. A dual-wing wing with bending and torsion sheathing is used together with the power set of the wing.

The longitudinal set includes spars and skins, reinforced with stringers, to the transverse rib. The runners are made of mechanically treated shelves and walls, having a thickness gradually decreasing to the end part of the wing. The shelves are milled from the extruded sections of the T-section. The sides of the spars are reinforced with stamped posts.

The wing has a relatively small distance from the ground, resulting in an increase in the lift factor CY due to the influence of the ground, thereby improving the takeoff and landing characteristics.

The horizontal plumage relative to the wing is exceeded, which has a positive effect on longitudinal stability and controllability.

The slightest danger for the aircraft and passengers when landing with the landing gear that is not activated, the wing takes the energy of the impact, protecting the passenger cabin; As the water enters, it plunges into water along the wing, giving the plane a buoyancy that can help.

The wing is made swept, as a result of which it has a larger MKP and a weaker wave crisis, but there are a number of drawbacks:

.Large tearing speeds and landing and, as a consequence, a long run and run length.

. It has smaller aerodynamic qualities than direct, greater drag of the aircraft and a shorter range, and the duration of the flight.

. Have a tendency to end the flow from the wing.

Lowest coefficient of maximum lift.

.External lateral stability, leading to aircraft swinging.

. The lateral controllability is reduced at large angles of attack due to a stall from the wing ends, has a reverse roll response.

1.1.5 Tail unit

The aircraft's tail unit is made up of a fin with a rudder and stabilizer. Stabilizing deflectors are located on the nose. The trimmer is installed in the lower section of the second rudder link. The rudder has aerodynamic balance and mass balance.

The horizontal tail unit includes the stabilizer consisting of two elevators with horn and forward balance.

The stabilizer represents the metal design consisting of two spars, ribs and panels.

Elevator is one-spar metal design with a set of ribs. The vertical tail unit consists of a fin and a rudder.

All FIN is a design consisting of two stringers of a set of stringer ribs and panels. The front edge of the fin has the part where it can be electrically heated. The trailing edge of a fin is carried out one type of panelswith metal coverings and PSP panels.

The rudder is made of metal, a set of ribs and a cover. In the initial part the spring trimmer servo compensator is installed. All the trimmed surfaces of the plumage: the design of a mobile device that helps to spy on the networks

1.1.6 Crew cabin

The modification of the workplaces of the officers provides to any of them the security of the airplane. The stability and controllability characteristics of the aircraft, the structure, characteristics and on-board systems, the structure and modification of the equipment provide pilots with the performance of their functional duties without exceeding the standards.

The tapered windshield application of a new version of the crew cabin provides a good overview for pilots and satisfies the requirements of flight operation under expected conditions.

The installation of the light signaling devices, which is in the control panel of the pilots, is carried out with the agreement and the requirements of the flight airworthiness regulations. On the control peak in the zone of the best range, in the review quickly used control panels of control radio stations and automatic control systems are located.

On the top control panel of onboard systems are placed fuel, hydraulic, power supply, anti-icing, air conditionings, start of engines and APU, fire extinguishing switches and a board of the warning alarm system.

The navigation and landing equipment panels are also placed in the central pilot panel.

1.1.7 Passenger furnishing

The aircraft passenger equipment provides the necessary amenities that are required in the aircraft where there are adjustable pilot chairs, flight assistance seats and passenger seats; light protection blinds

, clothes and toilet. Between a passenger cabin and a kitchen compartment the easily removable door is established.

Between a cabin of crew and a passenger cabin the toilet room is placed (on the right board) and compartment equipped with emergency equipment. The area of the toilet room is 1 square meter.

In a toilet are located a tank with water and technical liquid. In a toilet the toilet bowl of water vacuum type is established. Onboard there are three first-aid kits (one in a crew cabin, one is included in structure of crash equipment and one - in tail part).

The emergency includes a specified amount of ropes, oxygen masks, smoke-proof masks, the manual fire extinguisher, first aid kits, emergency radio stations, illuminated escape routes, emergency lighting, with a "EXIT" notice near each emergency exit, life jackets at the workplaces of the crew and the flying customer, fake life jackets on the crew members and passengers.

1.1.8 Control system

The aircraft control system includes: elevator control system, stabilizers, rudder, ailerons, air brakes, flaps and slats.

Main control system of the aircraft is an indirect action, automated. The operation of the system in the main mode is provided by four multiply duplicated hydraulic systems and on-board flight-navigation digital complex. To fix the rudders and ailerons in the parking lot, a locking system is provided, which is driven by electro mechanisms.

Control of the electro mechanisms of the locking is carried out on the central control panel of the pilots.

1.1.9 Landing gear

The chassis of the aircraft is three-bearing. The basic supports have beams-beam racks and four-wheeled carts equipped with brake wheels with high-pressure pneumatics. The front support is equipped with two high-pressure brake wheels, the wing and fairings of the chassis are made of composite materials.

The aircraft has a control system for turning the front support, this improves the maneuverability of the aircraft during taxiing.

The main chassis supports have a hydraulic braking system for wheels and devices that automatically adjust the braking force of the wheels, which eliminates the emergence of a yuz.

1.1.10 Power plant

The power plant of the plane consists of D-436-148 turbojets, located on pylons under a wing, at a small distance from the symmetry of the plane, and the auxiliary power unit located in the left fairing of the power plant.

The scheme of the D-436-148 engine two-shaft, with the three-stage fan, and the ten-step supersonic compressor. An engine oil system — circulating, closed, under pressure. All units of an oil system, including oil tank, are mounted on the engine. The system of regulation of the engine turns on the equipment of regulation of the fuel and an electronic control system.

Control of an operating mode of engines is exercised manually or automatically — from system of automatic control of a plane.

System of starting of engines is air type, with automatic equipment of control and electric ignition of fuel. Air for starting is selected from the auxiliary power plant, an airfield source or from other earlier started D-30 engine. Starting is carried out by means of an air starter of SV-36 established on the engine. The Auxiliary Power Plant (APP) represents the single-shaft gas-turbine engine with system of selection of air behind the compressor. This engine is an auxiliary energy link of the plane which provides on the ground and in flight air start of mid-flight engines, feed with compressed air of central air driving units, receiving the electric power of alternating current for an onboard network at service in the airfields located at the heights up to 4,5 thousand meters. Air start of mid-flight engines is provided when flying at the heights up to seven thousand meters, and power supply of units with air and the electric power — at the heights up to nine thousand meters. Air conditioning system works on the ground, during take-off, and flying at the heights up to 4,5 thousand meters.

Conclusion for Analytical part

In the new topic I have prepared the analysis of aircraft prototypes, made a choice of the characteristics of the designing aircraft, a fast description of all parts. Also we have done selection of engines which meet the requirements for the designed aircraft, determined the geometrical and structural parameters of the fusalege layout.

2. SPECIAL PART

2.1. General description of the primary controls of the aircraft

The primary flight controls are the flight controls in each phase of flight. The primary flight controls on the design aircraft are supported by a Power Control Unit. The wing and flight spoilers are used to make it roll more easily

The elevator is used to give a level of inclination to the aircraft and to be able to be connected without any problem to the horizontal stabilizer, it can also be moved by means of systems such as the automatic pilot adjustment. The rudder is used to lower the aircraft, with yaw damping aids in various tasks such as damping gusts and coordinating turns. Now let's take a look at how these systems work.

The elevator can be operated with three systems. The control column is the manual form where the guain drivers control the playing field. The Captain and First Officer control columns. then they go to the elevator touch centering unit, which is located in the tail cone and has the same function as the aileron touch and centering unit. From this point the cables are routed to the elevator PCUs, which move the elevator. The elevator PCUs work with type A and B hydraulic systems.

The autopilot is the second way to control the elevator. The autopilot sends a signal to the probe and the centering unit. This signal is combined in the Elevator Feel Computer with the position of the stabilizer, pitot-static inputs and hydraulic pressure. The Elevator Feel Computer then sends a signal to the elevator PCU’s to move the elevator and adds feel to the control columns via the Feel and Centring Unit.

The third way by which the elevator is controlled, is the mach trim. This is an automated system that eliminates the effect of the airplane pitching down at speeds approaching the speed of sound. The system operates at speeds above Mach 0.615. The Air Data Inertial Reference Unit (ADIRU) senses the airspeed via the pitot-static tube and sends a signal to the Flight Control Computer (FCC). The FCC sends a command to the Mach trim actuator, which in turn sends a signal to the elevator Feel and Centring Unit. The Feel and Centring Unit moves the elevator via the PCU's and adds feel to the control column.

Pitch trim is applied to the stabilizer. The stabilizer can be moved by four systems. The stabilizer trim is operated through the wheel on the side of the control stand on the pedestal. A scale indicates how much the stabilizer is trimmed. The green band shows the safe takeoff trim range.

On the left side of the scale is the trim wheel itself. The inputs of this wheel are send to the stabilizer trim part of the trim motor in the tail cone. The trim motor then adjusts the position of the stabilizer. This is a manual way of trimming and is normally not used.

The main electric trim is the second way in which the stabilizer is moved. The main electric trim is operated through two switches that can be moved up and down on the control wheel. The trim switches move the trim wheel and uses the same system as the stabilizer trim. The speed of the trimming depends on the speed of the aircraft. If the aircraft flies at a low airspeed, the trimming is faster than when the aircraft flies at higher speeds.

The autopilot trim is the third way the stabilizer is controlled. It sends a direct signal to the auto-pilot part of the trim motor, which moves the stabilizer to the commanded position.

The speed trim is the last system, and it operates at low speeds, aft centre of gravity, low gross weight and high thrust conditions, such as takeoff and go around procedures. It helps the pilot in controlling the aircraft in critical situations.

2.2. Elevators and stabilizer design and maintenance

The hinge assembly of aerodynamic control surfaces is made in the form of a hinged mechanism formed by two forming elements, one of which belongs to the bearing surface and the other of the control surface connected by overlapping of the flexible elements, for example in the form of strips with the formation of a mating line that is the axis of rotation of the hinge mechanism. The forming elements in such a way that the axis of rotation of the hinge mechanism is movable relative to the surface of the shaping element in the range of rotation of the control surface, typically 30°.

The invention relates to aeronautical engineering, in particular to devices for fixing stabilizers of aircrafts. The purpose of the invention is to ensure the quick-release of the stabilizer by simplifying the attachment points. The device for connecting the stabilizer to the fuselage of the aircraft contains front and rear attachment points, including bolts and nuts. The bolts are fitted with self-aligning bearings. Protuberances on the stabilizer arms. The bearings of the front attachment points are installed in the clips fastened to the fuselage brackets. The rear attachment points are equipped with eccentrics, enclosing the bearings and placed in the cages, in which horizontal grooves are made. The invention makes it possible to ensure a quick detachment of the stabilizer .

The position of the stabilizer along the length of the aircraft is regulated by locating washers located between the ends of the projections and the inner rings of bearings

The installation of bearings in the front assemblies 3 allows for small angular deviations of the rear part of the stabilizer 1 to install the entire stabilizer in the required flight position. After fastening in the front nodes, the rear pins are fixedly fixed by the rear fuselage units.

The rear knots on the fuselage are adjustable, it is allowed to shift their center in the horizontal and vertical planes within the required limits. Displacement of the unit horizontally (perpendicular to the direction of flight) is carried out by means of horizontal grooves made in the clips Vertical displacement is carried out by turning the eccentrics in the holes of the clips

Access to the bearing assemblies is difficult and in the event of a clogged bearing requires the opening of the basic design of the control element or equipment by its special hatches to access the bearing to replace it.

The technical goal of the invention is to reduce the weight of the structure, increase its service life, reduce the drive force, improve the maintainability of the hitch assembly.

In the process of aircraft operation a complex scheduled work related to its support in good and working condition is performed. Depending on the purpose of work the types of maintenance can be divided into the following:

- Monitoring the technical condition (inspection, testing parameters state service facilities, checking the operation and operating parameters of objects);
- Gas and oil (control the availability and replenishment of fuel, special liquids and gases);
- Cleaning works (removal of dirt that had accumulated, ice, snow);
- Remediation (fixing, adjusting, repairing, dismantling and assembling for prophylactic replacement products);
- Auxilliary works (access to facilities maintenance, lifting and hanging the aircraft, cleaning facilities from contamination prior to maintenance, demolition and construction works for maintenance).

Most maintenance works is such that repeated on all or most types of aircraft operated. Such works can be considered typical in maintenance. Presence of a list of typical works facilitates the formation of the basic program of maintenance for new aircraft.

In this work I will be talking about the inspection of the elevators hinges for corrosion prevention.

Corrosion can occur on diffierent part of the stabilizers with metallic properties;

- Corrosion has been found on the horizontal stabilizer rear spar, and filiform corrosion can occur on the inspar skin.
- Corrosion has been found at the faring surfaces of the inspar skin and inspar rib chords.
- Corrosion has been reported on the rear spar attachment bolts which may result in chrome plating flaking.
- Corrosion has been found on the stabilizer and stabilizer center section clevises and lugs.
- Corrosion and plating deterioration can occur on hinge pins at the horizontal stabilizer center section.
- Corrosion has been found between the horizontal stabilizer skin panel and the forward flange of upper and lower trailing edge beams. The corroded areas, two to ten inches long, were found at several locations along the beam between elevator stations. Corrosion is caused by water trapped in the unsealed seam.
- Corrosion has been found on the elevators hinges attachment lugs.
- Stress corrosion can cause broken lower attach bolt on the elevators. The attach bolts are made of a special alloy steel.
- Corrosion has been found in the stabilizer center section attach fittings. The deepest corrosion was found on gap between the two flanged bushings in the lug holes. Corrosion spots can also occur on the lug faces.
- Corrosion can occur on the elevator balance panels and similar structure to the elevator front spar.
- Corrosion can occur between elevator nose skins and hinge fittings for elevator balance panels, and between hinge halves and adjacent faying structure.
- Moisture can exist between the trailing edge skin panel mating surfaces.

Main procedure of elevators hinges maintenance for corrosion protection

- At first opportunity consistent with the scheduled maintenance activity, apply corrosion prevention treatment to the horizontal stabilizer.
- Periodically inspect the stabilizer for damaged finish and evidence of corrosion.
- Restore any damaged finish at the first opportunity. Apply water displacing corrosion inhibiting compound as the temporary corrosion protection meanwhile. On skin surfaces, apply corrosion inhibitor to rivet heads and panel edges where the paint has cracked or flaked and after 30 minutes wipe off the excess with a clean, dry rag.
- Apply water displacing corrosion inhibiting compound annually to the aft side of the rear spar cavity. Pay particular attention to attachment points and faying surfaces.
- Apply water displacing corrosion inhibiting compound annually to the fastener heads and skin joint on the upper and lower surfaces at the rear spar. Wipe off the excess with a clean, dry rag after a minimum of 30 minutes.
- Apply water displacing corrosion inhibiting compound annually to jackscrew support truss with particular attention to attachment points. Do not apply the compound on the jackscrew.
- Every 2 years, remove the leading edge, and spray water displacing corrosion inhibiting compound to the forward side of the rear spar with a proper extension tube. Pay particular attention to the upper and lower spar chords. Apply corrosion inhibitor at the intersection of skin and rib chords.
- Apply water displacing corrosion inhibiting compound annually to exposed areas of the elevator spar, with particular attention to the attachment points.

Caution: Do not apply corrosion-inhibiting compound to the seals of the elevator balance panel. Do not apply it to the areas that the seals will touch. The corrosion-inhibiting compound causes damage, or deterioration of the seals.

- Apply water displacing corrosion inhibiting compound annually to the elevator balance panels.
- Apply water displacing corrosion inhibiting compound to the horizontal stabilizer terminal fittings.
- Apply sealant, A00247 to prevent entrapment of water in the seams.
- Frequency of Application

(a) Periodic inspection is required in areas identified as susceptible to corrosion and should be consistent to the schedules specified in the Maintenance Planning Document. Operators must be aware of reported problems and areas of occurrences.

(b) Periodic application of corrosion inhibiting compound, G00009 is necessary to areas identified and should be consistent to the schedule specified in the Maintenance Planning Document.

Conclusion to the maintenance part

In this part of my diploma work we considered the main operational moments, design of the hinges assembly of elevators and stabilizer. The invention is to reduce the weight of the structure, increase its service life, reduce the drive force and allow a quick detachment of the stabilizer. It has been proposed the procedure of corrosion protection of hinges of elevators and stabilizer.

GENERAL CONCLUSIONS TO THE DIPLOMA WORK

During this designing work I've got the next results:

- preliminary design of the middle range aircraft with 150 passengers;

- the schematic design of the layout of the middle range aircraft with 150 passengers;

-the center of gravity of the airplane calculations;

-the calculation of the main geometrical parameters of the landing gear;

-the chose of the wheels, which satisfy the requirements;

- the design of elevators attachments.

The chosen design of low-wing aircraft with two engines, which are located under the wing, which is easier to access for maintenance and refilling, easier to stick main gear on, don't block any of the cabin.

The maximum level of passenger comfort provides:

-rational layout and convenient service facilities;

- ergonomic optimization of common and individual space;

- modern interior design;

- low noise;

Installation of turbofan engines type, CFM 56-3 modern engines on the aircraft that meet all standards of ICAO regarding noise and harmful emissions, enables customers international flight traffic.

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