МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
Кафедра конструкції літальних апаратів

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
д.т.н., проф.
_____________ Сергій ІГНАТОВИЧ
«_____» ___________ 2022 рік

ДИПЛОМНА РОБОТА
ЗДОБУВАЧА ОСВІТНЬОГО СТУПЕНЯ "БАКАЛАВР"
ЗІ СПЕЦІАЛЬНОСТІ
«АВІАЦІЙНА ТА РАКЕТНО-КОСМІЧНА ТЕХНІКА»

Тема: «Аванпроект середньомагістрального літака пасажиромісткістю 189 осіб»

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Київ 2022

MINISRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
Department of Aircraft Design

PERMISSION TO DEFEND
Head of the department
Dr.Sc., Professor
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«___» _______ 2022

BACHALOR DEGREE THESIS
ON SPECIALTY
"AVIATION AND AEROSPACE TECHNOLOGIES "

Topic: «Preliminary design of a mid-range aircraft with 189 passenger capacity»

Prepared by: __________ **Gan Hongyu**

Supervisor: PhD, associate professor __________ **Sviatoslav Yutskevych**

Standard controller: PhD, associate professor __________ **Sergiy KHIZNYAK**

Kyiv 2022

NATIONAL AVIATION UNIVERSITY

Aerospace Faculty

Aircraft Design Department

Educational degree «Bachelor»

Speciality 134 "Aviation and Space Rocket Technology"

APPROVED BY
Head of the Department
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_________ Sergiy IGNATOVYCH
«____ » ____________ 2022

TASK
or the bachelor degree thesis

GAN HONGYU

1. Topic: «Preliminary design of a mid-range aircraft with 189 passenger capacity» confirmed by Rector's order № 489/ст from 10.05.2022.

2. Thesis term: from 23.05.2022 to 19.06.2022.

3. Initial data: cruise speed V_{cr}=820 kmph, flight range L=4000 km, operating altitude H_{op}=10.6 km, 189 passengers.

4. Content (list of topics to be developed): choice and substantiations of the airplane scheme, choice of initial data; engine selection, aircraft layout, center of gravity position calculation, conceptual design of temperature-adjustable air seats.

5. Required material: general view of the airplane (A1×1); layout of the airplane (A1×1). Graphical materials are performed in AutoCAD.

6. Thesis schedule:

Task	Time limits	Done
Task receiving, processing of statistical data	23.05.2022–28.05.2022	
Aircraft geometry calculation	28.05.2022–31.05.2022	
Aircraft layout	31.05.2022–03.06.2022	
Aircraft centering	03.06.2022–05.06.2022	
Graphical design of the parts	05.06.2022–12.06.2022	
Completion of the explanation note	12.06.2022–14.06.2022	
Defense of diploma work	14.06.2022–19.06.2022	

7. Date: 23.05.2022

Supervisor ___________ Sviatoslav Yutskevych

Student ___________ Gan Hongyu

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Аерокосмічний факультет

Кафедра конструкції літальних апаратів

Освітній ступінь «Бакалавр»

Спеціальність 134 «Авіаційна та ракетно-космічна техніка»

Освітньо-професійна програма «Обладнання повітряних суден»

ЗАТВЕРДЖУЮ
Завідувач кафедри, д.т.н, проф.
__________ Сергій ІГНАТОВИЧ
«_____» _____________ 2021 р.

ЗАВДАННЯ
на виконання дипломної роботи студента

ГАН Хунюй

1. Тема роботи: «Аванпроект середньомагістрального літака пасажиромісткістю 189 осіб», затверджена наказом ректора № 489/ст від 10 травня 2022 року.

2. Термін виконання роботи: з 23 травня 2022 р. по 19 червня 2022 р.

3. Вихідні дані до роботи: максимальна кількість пасажирів 189, дальність польоту з максимальним комерційним навантаженням 4000 км, крейсерська швидкість польоту 820 км/год, висота польоту 10,6 км.

4. Зміст (перелік тем для розробки): вибір та обґрунтування схеми літака, вибір вихідних даних; вибір двигуна, компонування літака, розрахунок положення центру ваги, концептуальний проект повітряних крісел з регулюванням температури.

5. Перелік обов’язкового графічного матеріалу: загальний вигляд літака (А1×1), компонувальне креслення фюзеляжу (А1×1).

6. Календарний план-графік:

Завдання	Термін виконання	Відмітка про виконання
Вибір вихідних даних, аналіз льотно-технічних характеристик літаків-прототипів	23.05.2022–28.05.2022	
Вибір та розрахунок параметрів проєктованого літака	28.05.2022–31.05.2022	
Виконання компонування літака	31.05.2022–03.06.2022	
Розрахунок центрування літака	03.06.2022–05.06.2022	
Виконання креслень літака	05.06.2022–12.06.2022	
Оформлення пояснювальної записки та графічної частини роботи	12.06.2022–14.06.2022	
Захист дипломної роботи	14.06.2022–19.06.2022	

7. Дата видачі завдання: 23.05.2022 рік

Керівник дипломної роботи ___________ Святослав Сергійович

Завдання прийняв до виконання ___________ ГАН Хунюй

ABSTRACT

Explanatory note to the diploma work «Preliminary design of the mid-range passenger plane with 189 passenger capacity» contains:

57 pages, 17 figures, 8 tables, 11 references and 2 drawings

Object of the design is development of the mid-range aircraft with 189 passengers capacity.

The aim of the diploma work is the preliminary design of the aircraft and its design characteristics estimation.

The methods of design are: analyzis of the prototypes and selection of the most advanced technical decisions to calculate the geometry for main parts of the fuselage, such as wing geometry calculation, tail unit geometry, fuselage layout and landing gear design. Besides center of gravity calculation is another significant portion in the design.

The diploma work contains drawings of the mid-range aircraft with 189 passengers, calculations and drawings of the aircraft layout, airplane temperature-controlled air seats in conceptual design.

AIRCRAFT, PRELIMININARY DESIGN, LAYOUT, CENTER OF GRAVITY POSITION, AIPLANE TEMPERATURE-CONTROLLED AIR SEATS.

List of drawings

№ п/п	Name of drawings	Format	Number of sheets
1	Aircraft General View	A1	1
2	Aircraft Layout	A1	1

Introduction

Over the past decade, global air passenger demand has grown by an average of 5.5% per year. As shown in Figure 1. While the air passenger industry has been hit hard by COVID-19 for the past three years, air passenger demand will quickly return to normal as the outbreak subsides [1].

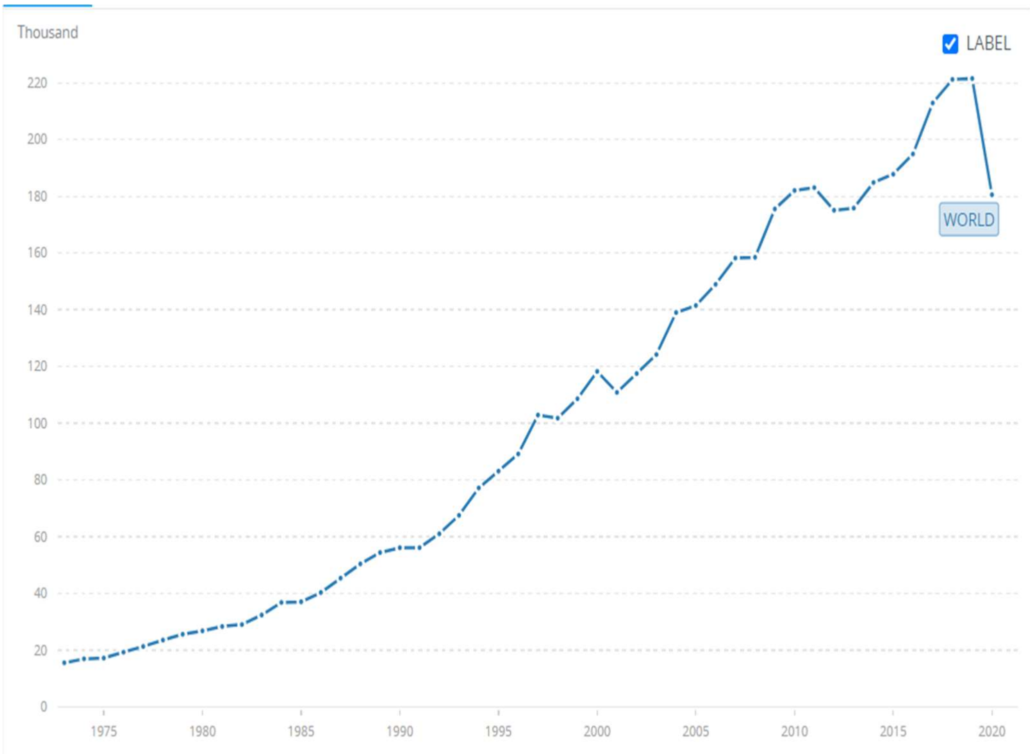

Figure 1 Flight demand in recent years

Air passenger transport has become an essential way for people to travel. People can reach anywhere in the world easily and quickly by plane and traveling around the world is no longer an unattainable dream for ordinary people. Economic globalization is the general trend of the world. With the continuous development of air passenger transportation, the economic cost of air travel is getting lower and lower. With the rise of some developing countries, the demand for medium-range aircraft will increase rapidly in the coming decades. Air travel will continue to grow and become one of the most important forms of travel.

Comparing passenger aircraft with cargo aircraft, for developing countries, the future demand for passenger aircraft may be greater than cargo aircraft. Take China as an example, as people's income levels continue to rise, people pay more attention to entertainment, and people will choose faster air travel instead of train travel. As for the transportation of goods, by road, train, or ship, it has more economical advantages than airplanes, especially for the transportation of many bulky or cheap goods. So according to domestic demand, passenger flights in China will increase rapidly in the coming decades.

Passenger aircraft are designed to transport passengers and their luggage. Passenger aircraft not only have the function of transporting passengers, but also have some of the cargo functions of cargo aircraft. Airliners are more concerned with comfort and passenger safety than the pursuit of large capacity. The airliner has several features, the first being a narrow fuselage cross-section, low-profile wings that provide high agility and safety in emergency situations, and quieter, more fuel-efficient engines for passenger comfort.

The successful maiden flight of China's first large passenger plane C919 with completely independent intellectual property rights marks the beginning of a new era of civil aviation in China. Therefore, our country urgently needs the design of trunk airliner, which is safer, more economical, more comfortable, and more environmentally friendly, and can be compatible with the western 150-190 seat class. Therefore, it is very necessary to carry out the preliminary conceptual design of medium-range aircraft.

Considering that the aircraft type is designed to carry about 189 passengers without refueling at nearly 4,000 kilometers, it can meet all domestic passenger requirements for flight distance or passenger capacity and is suitable for short- and medium-haul flights.

PART 1. ANALYZE OF PROTOTYPES

1.1 Short description of prototypes

The first step in starting this design is to select the prototype aircraft that will be used for analysis. The first general idea is to select representative and successfully designed aircraft, because the success of these aircraft embodies the wisdom and hard work of countless aircraft engineers. A successful aircraft must have its unique features and advantages, which can better reflect the needs of the modern aviation market are worth learning.

Airbus A320-neo is one of the best-selling aircraft in the history of civil aviation and has great research value, another reason is that it is like COMAC C919, which is the first large trunk airliner in China, compare them and learn their advantages. However, the number of passengers that the A320-neo can carry does not match the aircraft of this design[2].

The C919 is Chinese first large trunk airliner from COMAC. It is of great significance to the Chinese, but the flight range and maximum take-off weight are a little less than the aircraft designed this time. The aircraft designed this time is an aircraft that can fully meet the needs of any domestic route and medium-haul flight[3].

Next, the Boeing 737-800 Max that perfectly covers this design range and passenger capacity. After considering various parameters, Boeing 737-800 Max is the most suitable prototype for this design[4].

1.2 Geometrical and mass parameters, flight performances of the prototypes

To form a concept for the preliminary design of the aircraft, the optimal design parameters are first selected. The selection of aircraft parameters for the optimal design is a multidimensional optimization task. Its configuration implies a whole complex of flight technology, weight, geometry, aerodynamics, and economic characteristics.

The task at this stage is to analyze the initial data of various prototypes (see Appendix A). After putting the collected approximate data into the computer program to import different resources, collect more accurate initial data and start this design. The task of this paper is to design an airliner with a capacity of 189 passengers and a maximum range of 4,000 kilometers at a given payload.

In Tables 1.1 and 1.2, there are three different types of passenger aircraft with operational technical data and geometric parameters, with similar characteristics to the parameters of the aircraft designed this time. The selected prototypes are compared as follows:

Table 1.1 Technical data of the aircraft prototype

Prototype	Boeing 737-800 Max	C919	Airbus 320-neo
Type	airliner	airliner	airliner
Pilot/Aircrew Number	2/6	2/5	2/4
Number of passenger seats	168	156	117
Maximum take-off weight, kg	79010	72500	68000
Maximum payload, kg	20540	20500	19500

-Continuation of the Table. 1.1

Prototype	Boeing 737-800 Max	C919	Airbus 320-neo
The form of the fuselage cross-section	round	round	round
Maximum flight distance, km	5460	4075	6150
Cruising speed, km/h	828	960	828
Cruising altitude, km	11	10.7	11
Number and type of engines	2(CFMI CFM56-7B)	2(CEM International-1C)	2(CEM56-5B)
Take-off distance, m	2550	2000	2090
Landing distance, m	1190	1600	1230
Landing speed, km/h	220	250	250
Takeoff runway length, m	1940	1800	1500
Thrust (per engine), KN	117	130	120

Table 1.2 Geometric parameters of the prototype

Prototype	Boeing 737-800 Max	C919	Airbus 320-neo
Length of fuselage，m	38.1	38.9	37.6
Wingspan，m	34.32	33.6	34.1
Wing area，m^2	124.6	129.15	122.6

-Continuation of the Table. 1.2

Prototype	Boeing 737-800 Max	C919	Airbus 320-neo
FR	9.45	8.74	9.50
sweep angle	25	25	25
tail height， m	12.57	11.952	11.76
Fuselage diameter， m	3.76	3.96	3.95
Fuselage fineness ratio	10.5	9.82	9.5
Fineness ratio of front and rear units	2.86	3.64	2.95
mean geometric chord， m	4.48	4.23	4.19

PART 2. PRELIMINARY DESIGN OF AIRCRAFT

2.1. Geometry calculations of the main parts of the aircraft

When designing the layout of the aircraft, in this work need to calculate the relative positions of the aircraft's components and various types of loads (passengers, luggage, food, fuel, cargo, etc.), and compare the calculation results and various parameters[5].

Finally, choose the parameters that best meet the design requirements as a guide.

2.1.1. Wing design

The main components of the wing include ribs, spars, stringers, and skins as shown in Figure 2.1. The basic function of the wing structure is to form the streamline shape of the wing, and at the same time transmit the external load to the fuselage. The wing structure should have sufficient strength, stiffness, and life under external loads. Adequate stiffness refers to both the ability of the skin to maintain the shape of the airfoil under aerodynamic loads and the ability of the wing to resist torsional and bending deformations. The main functions of a wing are: Creating an elevator for an aircraft Wings must be designed and manufactured to maintain their shape even under extreme pressure. The wings must be strong enough to withstand the positive forces in flight as well as the negative forces in landing.

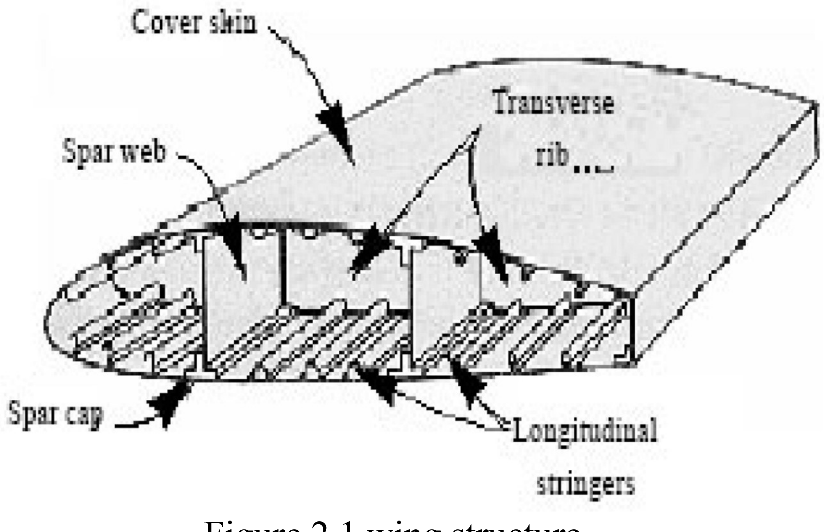

Figure 2.1 wing structure

According to the design requirements of this time, the mid-span airfoil is selected as the aircraft wing for this design. Figure 2.2 is a diagram of this airfoil.

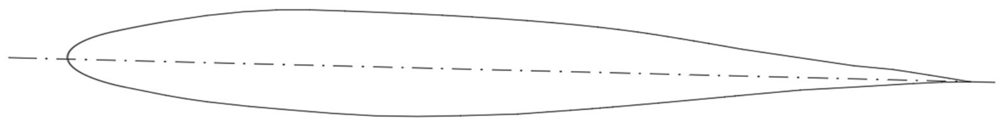

Figure 2.2 midspan airfoil

The aircraft's wing structure is a mid-span airfoil that generates enough lift to carry a useful payload. The wing roots are approximately 16.5% of the fuselage length. The maximum thickness is 12.5% and the string is 29.7%. Maximum camber is 0.8% at 10% chord. The twist angle at the root is 4 degrees, and the tip has no twist wing.

The geometric properties of the wing are determined by the weight m0 and the specific wing load P0.

Wing area is:

$$A_{wing} = \frac{m_0 \cdot g}{P_0} = \frac{88102 \times 9.8 \times 10^{-3}}{4.962} = 174.002 \text{ m}^2$$

Then in this work can find the wingspan by the aspect ratio. Check the initial data to get the aspect ratio of 9.46.

Wingspan is:

$$S_{wing} = \sqrt{A_{wing} \cdot AR} = \sqrt{174.002 \times 9.46} = 40.56 \text{ m}$$

From the initial data, the taper ratio TR can be found to be 3, from which the length of the root chord and the tip chord can be calculated respectively.

Root chord and Tip chord:

$$\frac{A_{wing}}{2} = \frac{(C_{root} + C_{tip})}{2} \cdot \frac{S_{wing}}{2}$$

$$TR = \frac{C_{root}}{C_{tip}}$$

$$C_{root} = 3.21\text{m} \qquad C_{tip} = 1.07\text{m}$$

The average aerodynamic chord (MAC) of the wing, the position of the center of gravity and the focal center of the aircraft are all relative to the average aerodynamic chord. It can be seen from Figure 2.3 below that the average aerodynamic chords are equal: bMAC=2.43m.

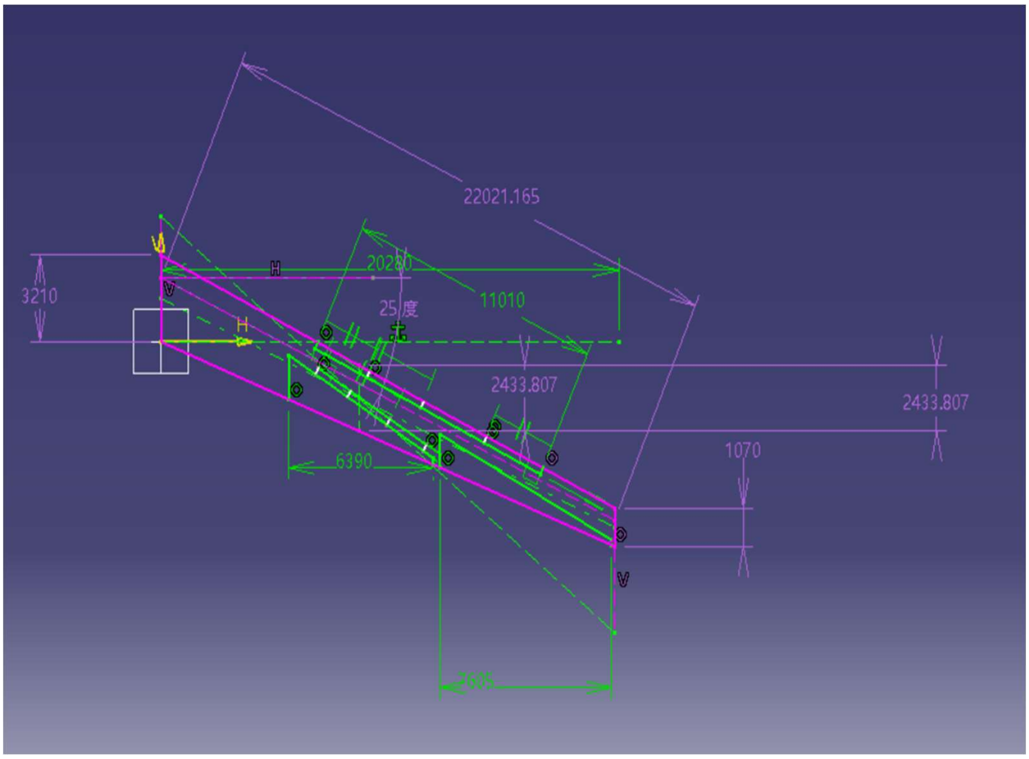

Figure 2.3 Determination of mean aerodynamic chord

After determination of the geometrical characteristics of the wing come to the estimation of the aileron's geometrics and high-lift devices.

Ailerons geometrical parameters are determined in next consequence:

Aileron's span:

$$S_{alieron} = 0.375 \cdot \frac{S_{wing}}{2} = 0.375 \times \frac{40.56}{2} = 7.605 \text{ m}$$

Aileron area:

$$A_{aileron} = 0.065 \cdot \frac{A_{wing}}{2} = 0.065 \times \frac{174.002}{2} = 5.66 \text{ m}^2$$

Tip of aileron:

$$A_{tip} = 0.24 \cdot C_{tip} = 0.24 \times 1.07 = 0.2568 \text{ m}$$

Root of aileron:

$$A_{aileron} = \frac{A_{root} + A_{tip}}{2} \cdot S_{aileron}$$
$$\rightarrow A_{root} = 1.2304 \text{ m}$$

In the modern design the rate of the relative chords of wing high-lift devices is:
bf = 0. 28..0.3 – one slotted and two slotted flaps.
bs = 0. 1..0.15 – slats.
Length of slats：

$$L_{slat} = 0.125 \cdot L_{chord} \cdot N_{slat} = 0.125 \times 22.021 \times 4 = 11.01 \text{ m}$$

Width of slat:

$$W_{slat} = 0.24 \cdot C_{tip} = 0.24 \times 1.07 = 0.2568 \text{ m}$$

Length of flap:

$$L_{flap} = 0.29 \cdot L_{chord} = 0.29 \times 22.021 = 6.39 \text{ m}$$

Root of flap:

$$F_{root} = 1.33 \cdot A_{root} = 1.33 \times 1.2304 = 1.64 \text{ m}$$

Tip of flap:

$$F_{tip} = 0.24 \cdot C_{tip} = 0.24 \times 1.07 = 0.2568 \text{ m}$$

Increasing of lail and bail more than recommended values is not necessary and convenient. With the increase of lail more than given value the increase of the ailerons coefficient falls, and the high-lift devices span decreases. With bail increase, the width of the xenon decreases[6].

In the airplanes of the third generation there is a tendency to decrease relative wing span and ailerons area. So, lail = 0.122. In this case for the transversal control of the airplane in this work use spoilers together with the ailerons. Due to this the span and the area of high-lift devices may be increased, which improves take off and landing characteristics of the aircraft.

Aerodynamic compensation of the aileron.

Axial Saxinail ≤ (0.25…0.28) Sail $= 0.26 \times 5.66 = 1.47$

Inner axial compensation Sinaxinail = (0.3..0.31) Sail;

Area of ailerons trim tab.

For two engine airplane: $S_{tail} = 0.05 \ldots 0.06 \cdot S_{ail} = 0.05 \cdot 5.66 = 0.28 m^2$

Range of aileron deflection

Upward δ'ail ≥ 20˚;

Downward δ''ail ≥ 10˚.

The aim of determination of wing high-lift devices geometrical parameters is the providing of take of and landing coefficients of wing lifting force, assumed in the previous calculations with the chosen rate of high-lift devices and the type of the airfoil profile.

Before doing following calculations it is necessary to choose the type of airfoil due to the airfoil catalog, specify the value of lift coefficient Cbw_{ymax} and determine necessary increase for this coefficient C_{ymax} for the high-lift devices outlet by the formula: $\Delta C \frac{C_{y\,max\,l}}{C_{y\,max\,bw_{ymax}}}$.

Where $C_{y\,max\,l}$ is necessary coefficient of the lifting force in the landing configuration of the wing by the aircraft landing insuring (it is determined during the choice is the aircraft parameters).

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

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 in this work need to come from the statistics and experience of domestic and foreign aircraft construction. In this work need to mention that in the majority of existing constructions elements of high-lift devices are done by longeron structurally-power schemes.

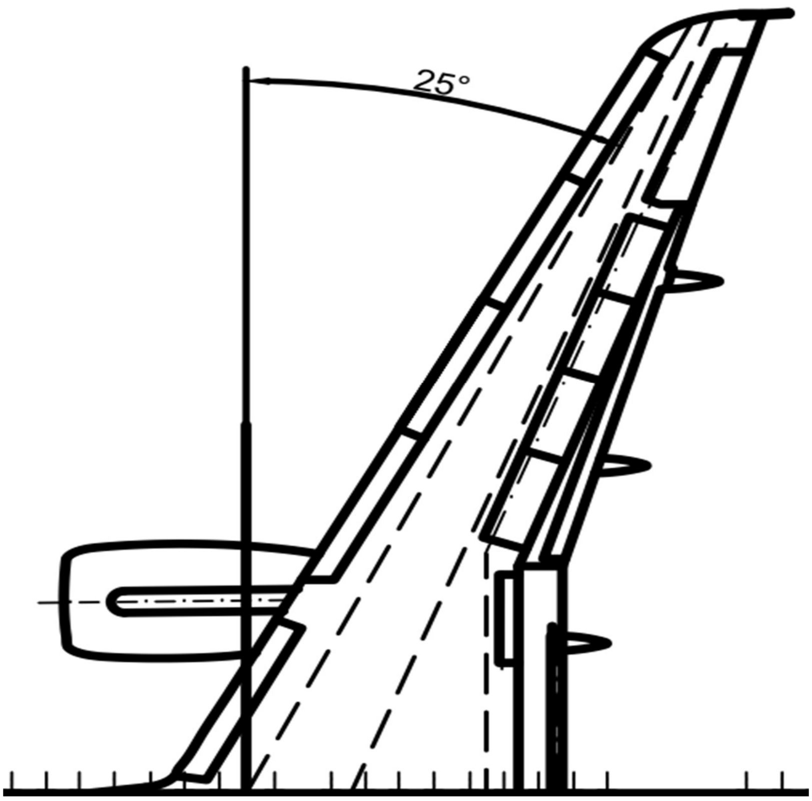

Figure 2.4 Top view of aircraft wing structure

2.1.2. Fuselage design and layout of the cabin

In this design work, the layout of the aircraft includes a structure that allows space to carry passengers, luggage, and other useful loads. The fuselage structure consists of bulkheads, frames, longitudinal and transverse beams, and skins as shown in Figure 2.5. The bulkheads and frame give shape to the skin of the aircraft. Mount the formers parallel to each other and along the perimeter of the entire surface by side members. Technically, the fuselage is divided into three parts: the front (cockpit), the middle (passenger compartment), the rear (tail unit) and the preliminary design of the aircraft layout is shown in Figure 2.6.

At the front is the cockpit, and the space below the cockpit accommodates many electronic instruments and other equipment, as well as the nose wheel of the landing gear. The tail of the fuselage consists of smaller forms, spars, and stringers. As the formers are smaller, but their thickness is constant, they are stiffer and therefore have no structural problems supporting both horizontal and vertical stabilizers. The APU (Auxiliary Power Unit) is usually placed at the tail.

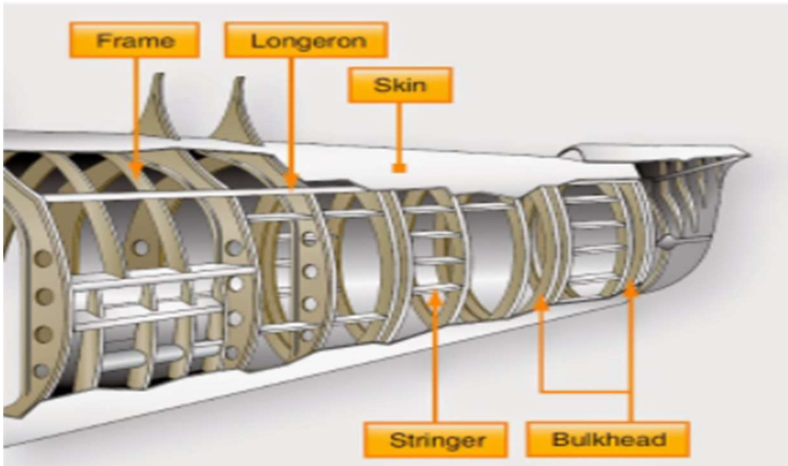

Figure 2.5 fuselage structure

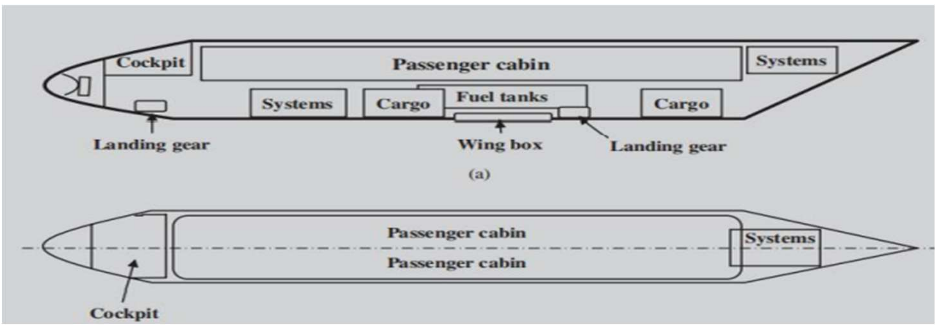

Figure 2.6 Preliminary design of aircraft layout

When choosing the airframe parameters, the aerodynamic requirements of the streamlined shape need to be considered.

The circular cross-section of the fuselage is the most efficient because it provides minimum weight and maximum strength, meeting strength requirements and reducing weight, which are important for aircraft design.

In addition to the above, designing an aircraft also focuses on geometric parameters such as: fuselage diameter, fuselage length, fuselage aspect ratio, nose, and tail units. In the design, the aircraft fuselage should be designed considering the plane layout, the position of the center of gravity of the aircraft and the landing angle of attack.

Fuselage length is equal:

$$L_{fuselage} = DF \cdot FR = 3.76 \times 11 = 41.36 \text{ m}$$

Length of the fuselage nose part is equal:

$$L_{nose} = \frac{4.25}{39.47} \cdot L_{fuselage} = \frac{4.25}{39.47} \times 41.36 = 4.5 \text{ m}$$

Length of the fuselage rear part is equal:

$$L_{rear} = \frac{1.0}{5.1} \cdot L_{fuselage} = \frac{1.0}{5.1} \times 41.36 = 8.1 \text{ m}$$

For midsize airliner airframes, the size of the cabin is important. Cabin height plays an important role in cabin size.

Cabin height is equal:

$$H_{cabin} = 1.48 + 0.1 \cdot B_{cabin} = 1.48 + 0.1 \times 3.75 = 2.1175 \text{ m}$$

Windows are lined up on each side of the fuselage. The shape of the window is a rectangle with rounded corners. Because aircraft windows are prone to stress concentrations, the corners of the windows are rounded. This window is located between the two bulkheads, in this design, the distance between the two windows is about 500 mm, as shown in Figure 2.7.

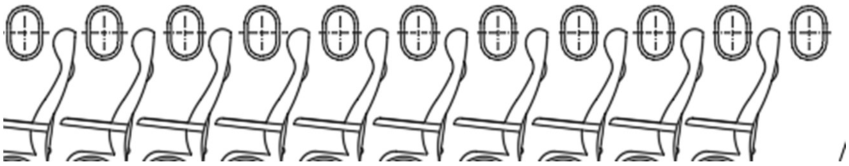

Figure 2.7 Cabin window arrangement

The entire aircraft is only equipped with economy class for medium-haul flights, and the passenger seats are designed to be 3+3 in each row. When calculating the width of the economy class, for three rows of seats, the total width is 1500 mm, the aisle width between the seats is 450 mm, the distance between the seats and the cabin panel skin is 50 mm, and the thickness of the panel skin is 100 mm. From these data, the following can be obtained to calculate the width of the cabin[7].

For three seats of one block distribution in this work may take the width as: (3*3)

economic class seat width $b_{3ec}=1455.....1650mm$;

The distance from the outside of the seat handle to the inner wall of the fuselage $\delta_1=40.....50mm$;

The distance between inner and outer walls of the fuselage $\delta_{wall}=80.....120mm$;

For aisle width we may take as:

$b_{ais\text{-}ec}=400.....510mm$;

$b_{asi\text{-}bu}=500.....600mm$;

$$B_{cabin} = N_{seat} \cdot L_{seat} + N_{aisle} \cdot L_{aisle} + \delta_{wall} + \delta_1 = 2 \times 1500 + 1 \times 450 + 2 \times 100 + 2 \times 50 = 3.75 \text{ m}$$

When calculating the length of the cabin, the seats should be laid out first. According to the design, there should be 32 rows of 3+3 seats. For the first row and the last row, a certain distance should be maintained between the front and rear flight attendant seats, respectively taking 250 mm. and 1200 mm, from which the length of the cabin can be calculated.

The length of passenger cabin is equal:

$$L_{cabin} = 1200 + (32 - 1) \times 870 + 250 = 28.42 \text{ m}$$

A cross-sectional view of the aircraft fuselage is shown in Figure 2.7.

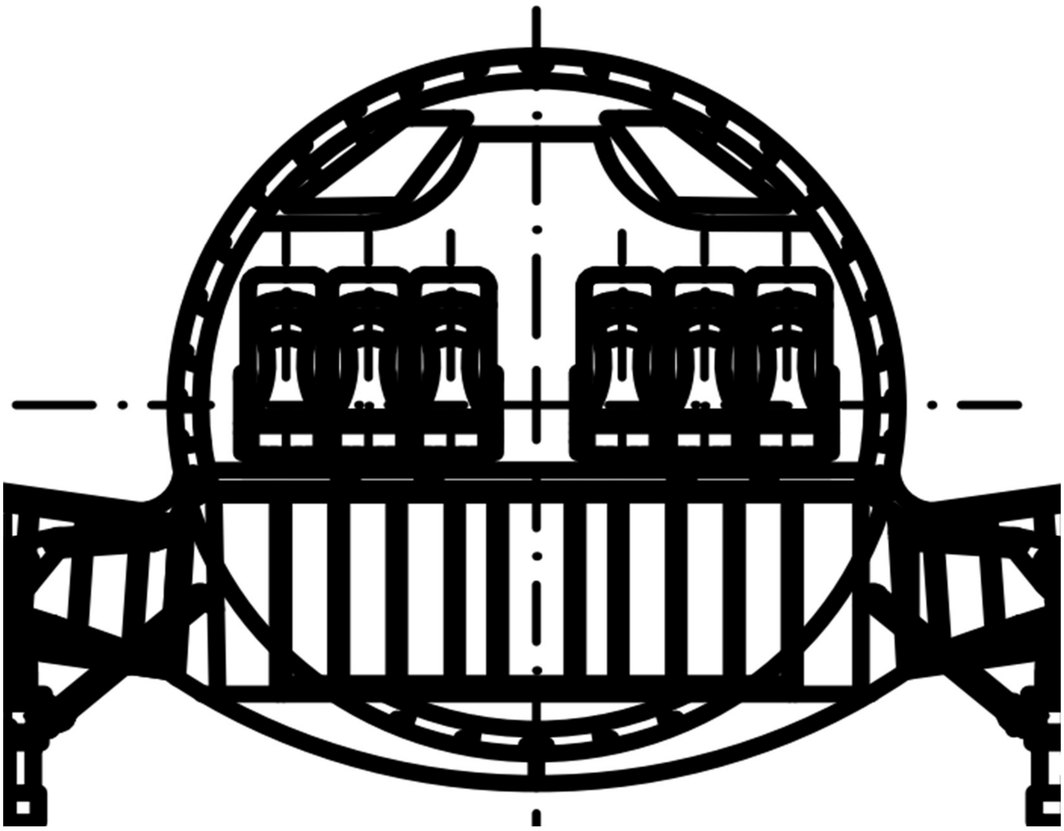

Figure 2.7 A cross-sectional view of the aircraft fuselage

Galleys and buffets

International standards stipulate that if the aircraft is made into a mixed layout, two things must be provided. If the flight time is less than 3 hours and no meals are delivered, tea will be provided in this case. If the flight time is less than one hour, no buffet will be provided. The kitchen cabinets must be close to the front door, preferably a separate door between the cockpit and the passengers. There are two galleys in the design of the aircraft, and they are located between economy class and business class

They are consisted of the kitchen structure, cabinet door components, garbage collection bins, carts, storage cabinets, water heaters, ovens, and related water system pipelines and electrical system wiring. Each cabinet is affixed with a corresponding label for easy identification. The movable parts in the kitchen are all locked with locks to prevent accidental sliding and falling of the plane when the plane is bumping and causing inconvenience to passengers. The garbage collection bins in the galley are made of flame-retardant materials to prevent fires.

The parameters of the kitchen will now be calculated.

According to international standards, the volume of the kitchen should be about 0.1 cubic meters per passenger, so the volume of the kitchen in this design is:

Volume of buffets(galleys) is equal:

$$V_{galley} = 0.11 \cdot N_{passenger} = 0.11 \times 189 = 20.79 \text{ m}$$

Area of buffets(galleys) is equal:

$$S_{galley} = \frac{V_{galley}}{H_{cabin}} = \frac{20.79}{2.1175} = 9.8 \text{ m}$$

Galley area distribution:

$$\text{S}_{G1} = 1.63 \times 1.5 = 2.45 \text{ m}^2$$

$$S_{G3} = 0.6 \times 1.35 = 0.81\text{m}^2$$

$$S_{G2} = S_{galley} - S_{G1} - S_{G3} = 9.8 - 2.45 - 0.81 = 6.54 \text{ m}^2$$

Lavatories

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.

The number of lavatories in this work choose according to the original airplane, and it is equal:

$$N_{lavatory} = \frac{189}{50} = 4$$

Area of lavatory:

$$S_{lavatory} = 0.75 \times 1.63 = 1.22 \text{ m}^2$$

Width of lavatory:0.75 m. Toilet's design like the prototype.

Lavatory and galley design as shown in Figure 2.8.

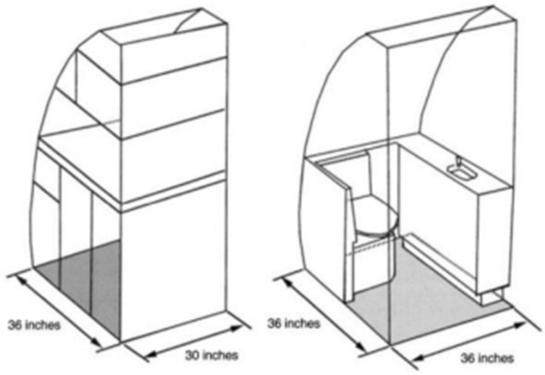

Figure 2.8 Lavatory and galley design

Fuselage layout as shown in Fig 2.9, 12 represents galley, 15 represents lavatory, 13 represents attendant, seat, 14 represents coat.

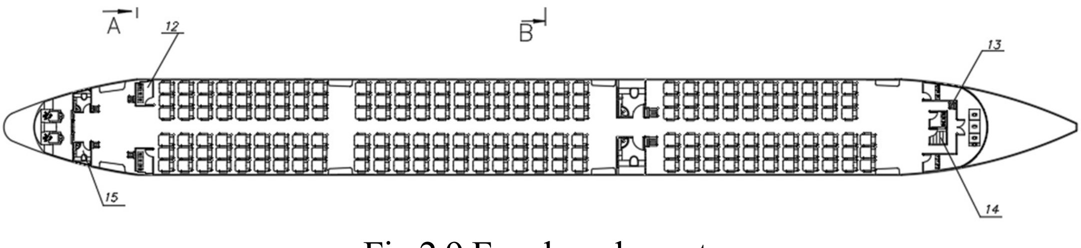

Fig 2.9 Fuselage layout

2.1.3. Tail unit design

In the following steps, the design of the aerodynamic layout of the tail unit will be considered, including the parameters of the vertical tail, horizontal tail, and tail unit arms. The horizontal tail is referred to as the horizontal tail, which is the airfoil for the longitudinal balance, stability, and control of the aircraft. The horizontal tail is symmetrically arranged at the tail of the aircraft, basically in a horizontal position. The front half of the tail is usually fixed and is called the horizontal stabilizer. The vertical tail is referred to as the vertical tail, which plays the role of maintaining the balance, stability, and control of the aircraft's heading. The principle is like that of the horizontal tail. The vertical tail is only arranged in the upper part of the aircraft axis[8].

To approximate the geometry of the tail unit, some data from the prototype aircraft can be referred to. It is not difficult to find the following calculation process from the aircraft design manual.

Determination of the tail unit geometrical parameters

Area of vertical tail unit is equal:

$$S_{VTU} = 0.16 \cdot A_{wing} = 0.16 \times 174.002 = 27.84 \text{ m}^2$$

Area of horizontal tail unit is equal:

$$S_{HTU} = 0.215 \cdot A_{wing} = 0.215 \times 174.002 = 37.41 \text{ m}^2$$

Length of center of gravity to VTU:

$$L_{VTU} = \frac{S_{wing} \cdot A_{wing} \cdot A_{VTU}}{S_{VTU}} = \frac{0.1 \times 40.56 \times 174.002}{27.84} = 25.35 \text{ m}$$

Length of center of gravity to HTU:

$$L_{HTU} = \frac{A_{wing} \cdot b_{CAX} \cdot A_{HTU}}{S_{HTU}} = \frac{0.725 \times 2.43 \times 174.002}{37.41} = 8.2 \text{ m}$$

Determination of the elevator area and direction:

Altitude elevator area:

$$S_{elevator} = 0.35 \cdot S_{HTU} = 0.35 \times 37.41 = 13.1 \text{ m}$$

Rudder area:

$$S_{rudder} = 0.21 \cdot S_{HTU} = 0.21 \times 27.84 = 5.85 \text{ m}$$

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:

$$S_{eb} = (0.22 \ldots 0.25)S_{el} = 0.24 \cdot 13.1 = 3.14\, m^2$$

Rudder balance area is equal:

$$S_{rb} = (0.2 \ldots 0.22)S_{rud} = 0.21 \cdot 5.85 = 1.23\, m^2$$

The area of altitude elevator trim tab:

$$S_{te} = 0.08 \cdot S_{el} = 0.08 \cdot 13.1 = 1.05\, m^2$$

Area of rudder trim tab is equal:

$$S_{tr} = 0.06 \cdot S_{rud} = 0.06 \cdot 5.85 = 0.35\, m^2$$

Root chord of horizontal stabilizer is:

$$b_{oHTU} = \frac{2S_{HTU} \bullet \eta_{HTU}}{(1+\eta_{HTU}) \bullet l_{HTU}} = \frac{2 \bullet 37.41 \bullet 3.25}{(1+3.25) \bullet 22.1} = 2.6$$

Tip chord of horizontal stabilizer is:

$$b_{0HTU} = \frac{b_{OHTU}}{\eta_{HTU}} = \frac{2.6}{3.25} = 0.8$$

Root chord of vertical stabilizer is:

$$b_{oHTU} = \frac{2S_{VTU} \bullet \eta_{VTU}}{(1+\eta_{VTU}) \bullet l_{VTU}} = 3.25$$

Tip chord of vertical stabilizer is:

$$b_{0VTU} = \frac{b_{OVTU}}{\eta_{VTU}} = 1$$

Tail unit swept back:

The swept horizontal tail is 30°, and the vertical tail is 30°, and the preliminary design of the horizontal stabilizer is shown in Figure 2.9.

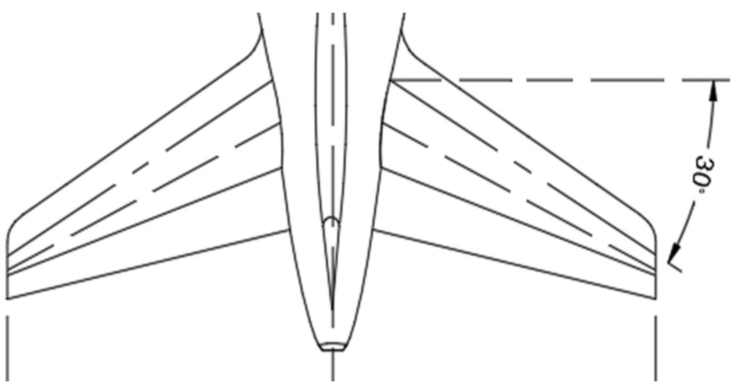

Figure 2.9 preliminary design of the horizontal stabilizer

2.1.4. Landing gear design

In the initial stage of design, when only the center of gravity of the aircraft is determined and there is no overall view of the aircraft, only part of the landing gear parameters can be determined. In this section, reference is also made to the Boeing 737-800 Max prototype.

Calculated according to the ratio of the prototype as shown in Fig 2.10.

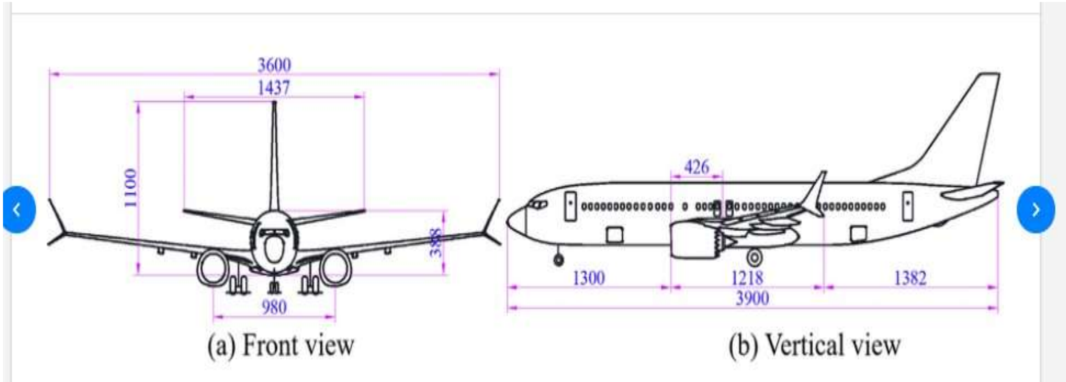

Fig 2.10 side view of prototype

Pitch is the distance between the main landing gear and the nose gear. The main landing gear is closer to the aircraft's center of gravity. During landing operations, the main wheel touches the ground first, and during take-off operations the main wheel leaves the ground last. Additionally, the main wheels carry most of the aircraft's landing loads. The schematic diagram of the landing gear layout is shown in Figure 2.11.

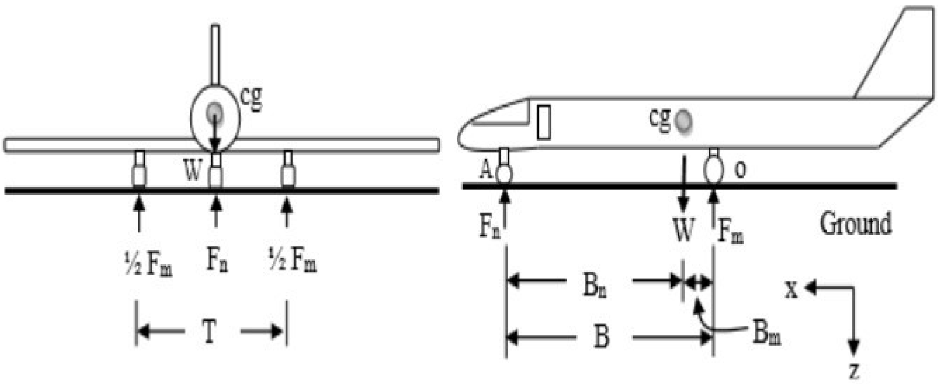

Figure 2.11 landing gear layout

Main wheel axel offset is:

$$Bm = (0.\ 15..0.20)\ b_{MAC}$$

$$B_m = 0.175 \cdot b_{MAC} = 0.175 \times 2.43 = 0.425 \text{ m}$$

With the large distance the lift of the nose gear during take of is complicated, and with small, the strike of the airplane tail is possible, when the loading of the back of the airplane comes first. Besides the load on the nose LG will be too small and the airplane will be not stable during the run on the slickly runway and side wind[9].

Landing gear wheelbase comes from the expression:

B = (0. 3..0.4) l f = (6...10%) Bm

$$B = \frac{4.4}{9.9} \cdot L_{fuselage} = \frac{4.4}{9.9} \times 41.36 = 18.38 \text{ m}$$

Large value belongs to the airplane with the engine on the wing.

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

The distance from the center of gravity to the nose LG

$$B_n = B - B_m = 18.38 - 0.425 = 17.95 \text{ m}$$

Wheel track is:

T = (0.7..1.2)B ≤ 12m

$$T = \frac{2}{9} \cdot S_{wing} = \frac{2}{9} \times 40.56 = 9.01 \text{ m}$$

On a condition of the prevention of the side nose-over the value T should be > 2H, where H – is the distance from runway to the center of gravity. So, take the distance H from the landing gear to the center of gravity as 4m, where H<9.01/2=4.505m.

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 tires and the pressure in it is determined by the runway surface, which should be used. In this work install breaks on the main wheel, and sometimes for the front wheel also.

$$F_{main} = \frac{(B-B_m)\cdot m_0\cdot 9.81}{B\cdot n\cdot z} = \frac{17.95\times 88102\times 9.81}{18.38\times 3\times 6} = 46892.3 \text{ N}$$

$$F_{nose} = \frac{B_m\cdot B\cdot m_0\cdot K_g}{B\cdot z} = \frac{0.425\times 18.38\times 88102\times 1.75}{18.38\times 2} = 32762.9 \text{ N}$$

Kg = 1.5...2.0 – dynamics coefficient.

where n, and z – is the quantity of the supports and wheels on the one leg.

By calculated Fmain and Fnose and the value of V take off and Vlanding, pneumatics is chosen from the catalog, the following correlations should correspond.

$P^K_{slmain} \geq$ Pmain ; $P^K_{slnose} \geq$ Pnose ; $V^K_{landing} \geq$ Vlanding ; $V^K_{take\ off} \geq$ Vtake off

Where--- K is the index designated the value of the parameter allowable in catalog.

The maximum load on the wheels and the speed of the aircraft when taking off and landing are considered when selecting tires, and some parameters from the prototype are also referred to, so the selected tires are shown in Table 2.1.

Table 2.1 – Aviation tires for designing aircraft

Main gear		Nose gear	
Tire size	Ply rating	Tire size	Ply rating
H31x13.0-12	20	24x8.0-13	18

2.1.5. Engine selection and description

The powerplant for the designed aircraft includes two CFM56-5B high bypass turbofan engines and an auxiliary power unit (APU) manufactured by CFM

International. This is a twin-shaft axial-flow high-bypass turbofan engine, its compressor consists of a fan, three-stage low-pressure and nine-stage high-pressure compressors, and the turbine includes one high-pressure stage and three low-pressure stages. The engine has a 5.5:1 compression ratio in cruise mode. The takeoff thrust of this engine ranges from 98 to 147kN. The length of the engine is equal to 260 cm and the diameter of the fan is 155 cm.

Examples of CFM56 turbofan engine applications are shown in Table 2.2.

Table 2.2 - Application examples of CFM56 turbofan

Model	Thrust（KN）	Bypass ratio	Length（m）	Dry weight (kg)	Applications
CFM56-5B	137	5.5:1	2.60	2500	Air 320 family
CFM56-5C	145	6.4:1	2.62	2544	Air 340-200/300
CFM56-7B	117	5.1:1	2.51	2400	Boeing 747 NG

The sectional view of the CFM56-5B engine model is shown in Figure 2.12.

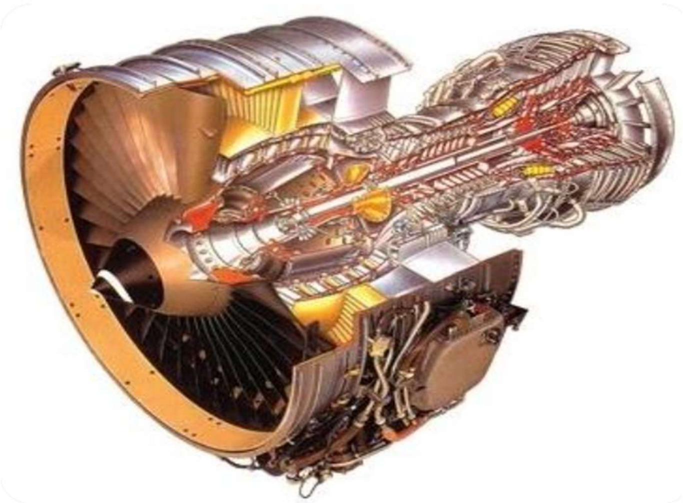

Figure 2.12 CFM56-5B engine

The CFM56-5B is an improvement on the CFM56-5A series originally designed to power the A321. With a thrust range of between 22,000 and 33,000 lbf (98 kN and 147 kN), it powers all models in the A320 series (A318/A319/A320/A321) and has replaced the CFM56-5A series. Changes to the CFM56-5A compared to the CFM56-5A include dual annular combustion chambers that reduce emissions (especially NOx), new fans in longer fan housings, and a new low-pressure compressor with a fourth stage (from three in earlier variants). It is the largest number of engines supplied to Airbus[10].

2.2. Center of gravity calculation

2.2.1 Trim sheet of equipped wing

Mass of the equipped wing contains the mass of its structure, mass of the equipment placed in the wing and mass of the fuel. Regardless of the place of mounting (to the wing or to the fuselage), the main landing gear and the front gear are included in the mass register of the equipped wing. The mass register includes names of the objects, mass themselves and their center of gravity coordinates. The origin of the given coordinates of the mass centers is chosen by the projection of the nose point of the mean aerodynamic chord (MAC) for the surface XOY. The positive meanings of the coordinates of the mass centers are accepted for the end part of the aircraft.

Many factors such as structural quality, fuel quality, landing gear quality, and the quality of equipment placed in the wing will affect the total mass of the wing equipment. All masses of a design aircraft wing are expressed as Table 2.3.

Table 2.3 Trim sheet of equipped wing

N	object name	Mass		C.G coordinates Xi, m	Mass moment, Xi * mi
		units	total mass m(i), kg		
1	wing (structure)	0.1176	10366.96	1.0449	10832.43
2	fuel system	0.0071	625.52	1.03275	646.01
3	Flight control system, 30%	0.0018	161.22	1.458	235.06
4	electrical equipment, 10%	0.0032	281.92	0.243	68.50
5	anti-ice system, 40%	0.0093	821.11	0.243	199.52
6	hydraulic systems, 70%	0.0119	1048.41	1.458	1528.58
7	power plant	0.1003	8838.39	-1.62	-14318.19

-Continuation of the Table. 2.3

1	2	3	4	5	6
8	equipped wing without landing gear and fuel	0.2513	22143.55668	-0.036491573	-808.053218
9	nose landing gear	0.0073	648.2897568	-15.6375	-10137.6310
10	main landing gear	0.0335	2953.320003	1.458	4305.940565
11	fuel	0.2411	21244.91628	1.0449	22198.81302
12	total	0.5333	46990.08272	0.331113895	15559.06929

2.2.2 Trim sheet of equipped fuselage

The origin of the barycentric coordinates is located at the distance from the nose part of the projection to the horizontal axis. The data of each component used for the computer body equipment are shown in Table 2.4.

Table 2.4 Trim sheet of equipped fuselage masses

N	objects names	Mass		C.G coordinates Xi, m	mass moment
		units	total mass		
1	fuselage	0.0965	8508.01	20.68	175945.64
2	horizontal tail	0.0121	1071.32	25.50	27318.66
3	vertical tail	0.0120	1057.22	25.00	26430.60
4	radar	0.0031	273.11	0.50	136.55
5	radio equipment	0.0023	202.63	0.80	162.10
6	instrument panel	0.0054	475.75	1.50	713.62
7	aero navigation equipment	0.0046	405.26	2.00	810.53
8	Flight control system 70%	0.0042	376.19	20.68	7779.72
9	hydraulic system 30%	0.0051	449.32	28.95	13008.71
10	electrical equipment 90%	0.0288	2537.33	20.68	52472.14
11	not typical equipment	0.0022	193.82	5.00	969.12
12	lining and insulation	0.0071	625.52	20.68	12935.84

-Continuation of the Table. 2.4

1	2	3	4	5	6
13	anti-ice system, 20%	0.0046	410.55	33.08	13584.45
14	air conditioning system, 40%	0.0093	821.11	20.68	16980.56
15	passenger seats (economic class)	0.0128	1134.00	22.08	25038.72
16	seats of flight attendance	0.0004	40.00	25.00	1000.00
17	seats of pilot	0.0003	32.00	3.50	112.00
18	Emergency equipment	0.0036	1206.00	21.68	26150.72
19	lavatory1, galley 1	0.0072	634.33	19.50	12369.52
20	lavatory2, galley 2	0.0072	634.33	36.78	23330.81
21	Operational items	0.0186	1645.74	26.00	30.74
22	additional equipment	0.0022	194.70	5.00	0.4300
23	equipped fuselage without payload	0.2501	22928.31	19.07	437281.26
24	Passengers(economy)	0.1651	14553	22.08	321330.24
25	on board meal	0.0032	283.50	32.68	9264.78
26	baggage	0.0429	3780	22.08	83462.40
27	cargo, mail	0.0070	625.13	24.40	15253.17
28	flight attend	0.0034	300	25.00	7500.00
29	crew	0.0017	154	3.50	539.00
30	TOTAL	0.4737	42623.94	20.51	874630.86

2.2.3 Centre of gravity calculations

The CG coordinates of the FEF are determined by formulas:

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

After determining the C.G. for the fully equipped wing and fuselage, we construct the moment balance equations with respect to the nose of the fuselage:

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

From here we determined the wing MAC leading edge position relative to fuselage, means Xmac value by formula:

$$X_{MAC} = \frac{m_f x_f + m_w \cdot x_w^{/} - m_0 C}{m_0 - m_w} = 20.35\text{m}$$

where m0 – aircraft takeoff mass, kg; mf – mass of fully equipped fuselage, kg; mw – 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) BMAC –low wing.

For swept wings; at X = 30°...40° C = (0,28...0,32) BMAC

at X= 45° C = (0,32...0,36) BMAC

After determining the position of the wings relative to the fuselage, the next step is to attach the wings to the fuselage. Then calculate the center of gravity of all equipment to have a new origin at the front of the fuselage (Table 2.5).

Table 2.5 Center of gravity position of the aircraft

Name	mass in kg	coordinate	mass moment
object	m_i	X_i, м	Kg.m
equipped wing (without fuel and landing gear)	22143.55	20.31	449835.11
Nose landing gear (extended)	648.28	5.30	3435.93
main landing gear (extended)	2953.32	22.24	65681.83
fuel reserve	3036.87	21.80	66231.17
fuel for flight	18208.04	21.80	397098.85
equipped fuselage (without payload)	22928.31	19.07	437281.26
Passengers(economy)	14553.00	22.08	321330.24
on board meal	283.50	32.68	9264.78
baggage	3780.00	22.08	83462.40
cargo, mail	625.13	24.40	15253.17
flight attend	300.00	25.00	7500.00

-Continuation of the table 2.5

1	2	3	4
crew	154.00	3.50	539.00
Nose landing gear (retracted)	648.28	4.50	2917.30
main landing gear(retracted)	2953.32	22.24	65681.83

Centering is the position of the aircraft's relative center of gravity to the leading edge of the mean aerodynamic chord, expressed as a percentage:

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

This is substituted into the coordinates corresponding to the centroid of Table 2.5. The calculation result of the center of gravity is the gravity at different operating positions of the center of gravity of the aircraft, see Table 2.6.

Table 2.6 Airplane's center of gravity position variants

N	Object name	Mass mi Kg	Mass moment kg*m	Center of masses Xc.g.	C.G.point X
1	take off mass (L.G. extended)	89614.02	1856913.78	20.72	0.25
2	take off mass (L.G. retracted)	89614.02	1856395.15	20.71	0.24
3	landing weight (LG extended)	71405.98	1459814.95	20.44	0.18
4	ferry version	70072.39	1419045.55	20.25	0.14
5	parking version	51710.35	1022465.33	19.77	0.13

The center of gravity will be in this range: 13.78% - 25.23%. The average aerodynamic chord length of the landing weight when the parking version is deployed is at most 13.78% of the front center of gravity, and the center of gravity of the aircraft is 25.23% aft when ferrying.

Conclusion to part 2

According to the task for Diploma paper, the following problems have been solved in the part 1:

- the preliminary design of the middle range aircraft with a capacity of 189 passengers;
- cabin layout of the medium range aircraft with 189 passengers;
-calculation the center of gravity of the airplane;
-calculatione the main geometrical parameters of the landing gear;
-the choice of the wheels, which satisfy the requirements;
- the choice of the wheel brakes obey the requirements;
- low-wing aircraft uses two engines under the wing;
- reasonable fuselage layout and convenient service;
- rational layout and convenient service facilities;
- ergonomic optimization of common and individual space;
- modern interior design;
- low noise.

The low-wing aircraft adopts a design with two engines under the wing, which can increase the aerodynamic characteristics of the wing, reduce the aerodynamic effect of engine jets, and reduce the noise level of the cabin.

The preliminary design meets the International and Chinese Airwortheness requirements.

PART 3. Conceptual design of temperature-adjustable air seats

3.1 Passenger Seat Design Requirements

The seat design process typically includes the following stages:

- The construction and development of the seat shall comply with geometrical parameters and safety requirements;
- Experimental test of static strength of seat;
- Experimental test of seat dynamic strength;
- Experimental testing of material flammability and toxicity;
- Experimental test of temperature regulation system;
- Obtain approval documents for the use of such equipment in aircraft.

3.2 General requirements for the design of air seat temperature adjustment devices

During medium and long-haul flights, many passengers feel impatient due to the temperature change in the cabin. This will not only lead to a poor travel experience, but also lead to a sub-health state, so it is necessary to increase the air seat temperature adjustment device to make passengers feel relieved. At the same time, the seat temperature adjustment is designed to serve not only the passengers but also the pilots in a further developed version when it can meet the requirements of the pilot seat when the more stringent requirements of Federal Aviation are met.

Several problems need to be solved in the design process of air seat temperature adjustment device:

- Find seat materials suitable for temperature adjustment;
- Transport the skin material into the seat by a suitable method;
-Adding the system to the rear seat still maintains the corresponding strength characteristics

-Choose the right pressure sensor;

-Provide security features;

- The seat material must be flame retardant to avoid fire due to excessive damage to the seat by the passenger. It also requires guidance material to demonstrate that the flammability of aircraft seat cushions complies with the relevant Federal Aviation Regulations (FAR) [11].

3.3 Overview of Air Seat Temperature Regulators

A temperature adjusting device provides a means for automatically adjusting the temperature of a seat and belongs to the field of aviation seats. It solves the problem in the prior art that the temperature of the seat cannot be adjusted, which causes passengers to feel uncomfortable. The device includes a controller with preset temperature upper limit value, temperature lower limit value and pressure upper limit value, a sensor arranged on the inner side of the front surface of the passenger seat back for detecting the temperature of the contact area between the human body and the seat back, at least one sensor is arranged on the inner side of the aircraft seat back, which is a fan for adjusting the temperature of the contact area between the human body and the seat back, temperature sensor-connected to the input of the controller, the fan is connected to the output of the controller, The input end of the controller is connected with a pressure sensor arranged on the inner side of the seat surface for detecting the pressure of the seat cushion. The device automatically and quickly adjusts the temperature of the air seat to make passengers feel comfortable.

Some requirements for air seat temperature adjustment devices:

Requirement one: Air seat temperature adjustment device, characterized in that the device includes a controller (1) preset with a temperature upper limit value, a temperature lower limit value and a pressure upper limit value 1 (2) temperature sensor arranged on the inner side of the front face of the passenger seat back for detecting the contact area between the human body and the seat back, at least one sensor is arranged on the inside of the aircraft seat back and is a fan used for temperature regulation of the contact area between the human body and the seat back, the temperature sensor one (2) is connected to the input end of the control instrument (1), and the fan is connected to the controller (1), the input end of the controller (1) is connected to a pressure sensor (4) disposed on the inner side of the upper surface of the passenger seat cushion for detecting the pressure on the cushion, and the controller (1) is used to receive The monitoring signal sent by the pressure sensor (4) and the temperature detected by the temperature sensor 1 (2) are received when the pressure is greater than the upper limit value. When the value is set, the fan will be controlled to adjust, and the fan will be stopped when the detected temperature falls to the lower limit of the temperature.

Requirement two: The air seat temperature adjustment device according to claim 1 is characterized in that the input end of the controller (1) should also be connected and arranged on the passenger seat cushion to indicate the inner temperature for detecting the temperature of the contact area between the person and the seat cushion The second (3) of the temperature sensor, the output end of the controller (1) is also connected with at least one fan arranged in the seat cushion of the passenger seat for adjusting the temperature of the contact area between the human body and the seat cushion, the controller (1) When it is judged that the pressure of the seat cushion is greater than the upper limit of the pressure, the detected temperature of the temperature sensor 2 (3) is processed and judged, and the controller (1) judges that the detected temperature is greater than or equal to the upper limit of the temperature, and controls the operation of the fan in the seat cushion to adjust the temperature and control the temperature. When the device (1) judges the lower limit of the detected temperature, it controls the fan in the seat cushion to stop.

Requirement three: The air seat temperature adjustment device according to claim 1, characterized in that, there are four fans arranged in the backrest of the passenger seat, which are fan one (5), fan two (6), fan three (7).) and fan four (8), the fan one (5), fan two (6), fan three (7), fan four (8) are respectively connected to the output end of the controller (1).

Requirement four: The air seat temperature adjustment device according to claim 2 is characterized in that, the device has two fans in the seat cushion of the passenger seat, which are fan five (9) and fan six (10) respectively, and the fan five (10) (9) and fan six (10) are respectively connected to the output terminals of the controller (1).

Requirement five: The air seat temperature adjustment device according to claim 2, 3 or 4, characterized in that, the input end of the controller (1) is respectively connected with a setting button one (11) for adjusting the upper limit of temperature and a setting button for adjusting the upper limit of the temperature. Temperature setting button two (12) to adjust the lower temperature limit.

Requirement six: The air seat temperature adjustment device according to claim 1, characterized in that, the input end of the controller (1) relates to a master switch (13) for controlling the device to be turned on and off.

The schematic diagram of the air seat temperature adjustment device is shown in Figure 3.1.

In the figure, controller (1), temperature sensor one (2), temperature sensor two (3), pressure sensor (4), fan one (5), fan two (6), fan three (7), fan four (8), fan five (9), fan six (10), temperature setting button one (11), temperature setting button two (12), main switch (13).

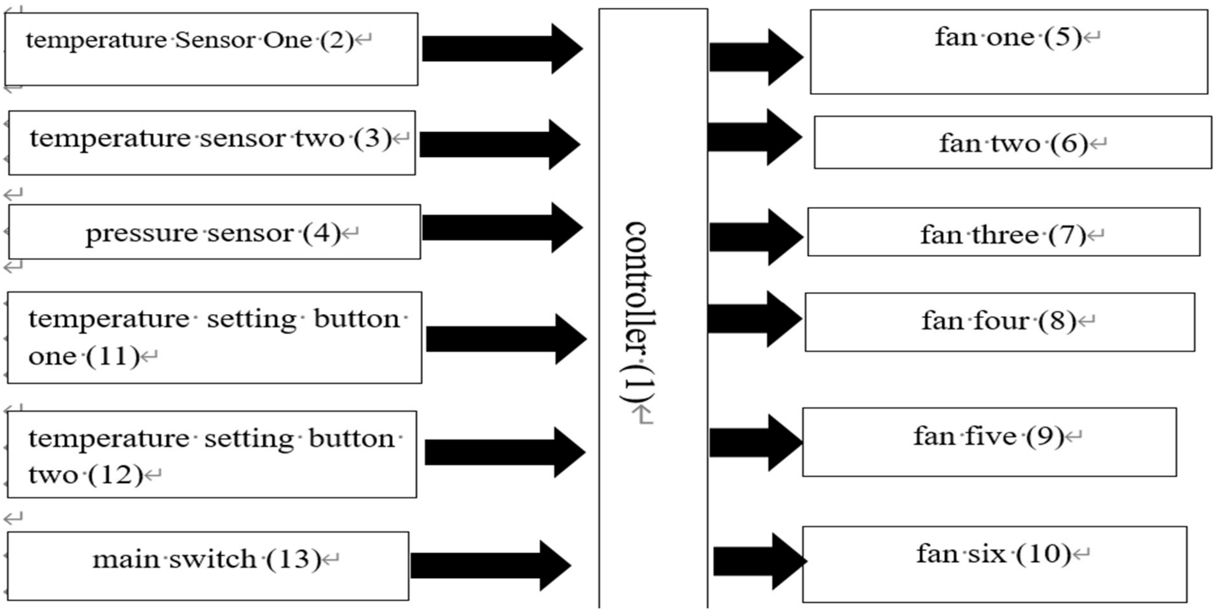

Figure 3.1 Schematic diagram of the structure of the air seat temperature adjustment system

3.4 Specific implementation method

The utility model is realized by the following technical solutions: an automatic cooling passenger seat device, characterized in that, the device comprises a controller with a temperature upper limit value, a temperature lower limit value and a pressure upper limit value preset, and is arranged on the passenger seat. A temperature sensor on the inner side of the front surface of the seat back for detecting the temperature of the contact area between the human body and the seat back—at least one fan installed in the car seat back for cooling the contact area between the human body and the seat back, the temperature sensor is connected to the control The input end of the fan is connected to the output end of the controller, and the input end of the controller is connected with a pressure sensor arranged on the inner side of the upper surface of the seat cushion of the passenger seat for detecting the pressure on the seat cushion, and the controller receives the pressure sensor When it is judged that the pressure of the seat cushion is greater than the upper limit of the pressure, the detected temperature of the temperature sensor is received for processing and judgment. The controller judges that the detected temperature is greater than or equal to the upper limit of the temperature and controls the fan to act to cool down. The controller judges that the detected temperature drops. Control the fan to stop when the temperature reaches the lower limit value.

The pressure sensor detects the pressure on the seat cushion of the passenger seat, and the controller receives the detection signal code sent by the pressure sensor in real time and performs judgment processing. When there is someone on the seat, the seat cushion of the passenger seat will receive a certain pressure. At this time, the controller judges that the pressure of the seat cushion is greater than the upper limit value of the pressure by receiving the detection signal sent by the pressure sensor, and the controller starts to receive the detected temperature sent by the temperature sensor. And make processing and judgment, the controller compares the current detected temperature with the temperature upper limit value, when the detected temperature is greater than or equal to the temperature upper limit value, it means that the person sitting on the passenger seat will feel stuffy, and the controller sends the control The signal is sent to the fan, and the fan rotates to cool the area where the person is in contact with the seat back of the car. At the same time, it also ventilates the area where the person is in contact with the back of the passenger seat. During this process, the controller directly receives the detected temperature sent by the temperature sensor. When the controller judges the temperature sensor. When the sent detected temperature reaches the lower temperature limit, the controller sends a control signal to the fan to control the fan to stop cooling, because the detected temperature reaches the lower temperature limit, that is, when the temperature of the area where the person and the backrest of the passenger seat contact is equal to the lower temperature limit , the temperature of the area where the person is in contact with the backrest of the passenger seat has reached the most comfortable temperature for the human body.

In the above-mentioned automatic cooling passenger seat device, the input end of the controller is also connected to a second temperature sensor for detecting the temperature of the contact area between the person and the seat cushion, and the controller output the end is also connected with at least one fan arranged in the seat cushion of the passenger seat for cooling the contact area between the human body and the seat cushion. The controller determines that the seat cushion is subjected to a pressure greater than the upper limit of the pressure and receives the temperature detected by the temperature sensor 2 for processing. Judging, the controller judges that the detected temperature is greater than or equal to the upper temperature limit and controls the action of the fan in the seat cushion to cool down, and when the controller judges that the detected temperature falls to the lower temperature limit, controls the fan in the seat cushion to stop the action. When a person sits on the passenger seat and the temperature of the passenger seat cushion is higher than the upper temperature limit, the controller automatically controls the fan to cool down the passenger seat cushion and cools down to the lower temperature limit, so that the person sits on the seat. The chair feels very comfortable.

In the above-mentioned automatic cooling passenger seat device, the number of fans disposed in the backrest of the passenger seat is four, which are fan 1, fan 2, fan 3 and fan 4 respectively. and fan four are respectively connected to the output terminals of the controller. By setting four fans to cool down, the cooling speed can be faster, and the cooling area can be wider so that people can quickly feel comfortable.

In the above-mentioned automatic cooling passenger seat device, there are two fans disposed in the seat cushion of the passenger seat, namely fan five and fan six, and the fan five and fan six are respectively connected to the output ends of the controller. Compared with the back of the passenger seat, the passenger seat cushion has a smaller area of contact with it, and two fans can be set up to quickly cool down.

In the above-mentioned automatic cooling passenger seat device, the input end of the controller is respectively connected with a temperature setting button 1 for adjusting the upper temperature limit value and a temperature setting button 2 for adjusting the temperature lower limit value. Everyone has a different feeling for heat. By setting these two buttons, people can adjust the required temperature by themselves, making the device more practical.

In the above-mentioned automatic cooling passenger seat device, the input end of the controller relates to a master switch for controlling the opening and closing of the device. When the person on the seat does not want to use the device, the device can be turned off through the main switch to make the wooden device more humanized.

As shown in Figure 3.1, the automatic cooling passenger seat device includes a controller 1 with a preset temperature upper limit value and a temperature lower limit value, which is arranged on the inner side of the front surface of the passenger seat back to detect the contact between the human body and the seat back A temperature sensor-2 for the area temperature, at least one fan arranged in the passenger seat back for cooling the area where the human body contacts the seat back. The fan is connected to the output end of the controller 1, and there are four fans arranged in the backrest of the passenger seat, namely fan one 5, fan 6, fan three 7 and fan four 8, fan one 5, fan two 6, fan three 7 and the fan four 8 are respectively connected to the output end of the controller 1. The temperature sensor 1 2 is connected to the input end of the controller 1, and the input end of the controller 1 is connected to a pressure sensor 4 arranged on the inner side of the upper surface of the seat cushion of the passenger seat for detecting the pressure of the seat cushion. The input end of the controller 1 is respectively connected with a temperature setting button one II for adjusting the upper temperature limit value, a temperature setting button II 12 for adjusting the temperature lower limit value, and a main switch 13 for controlling the opening and closing of the device.

The input end of the controller 1 is also connected to a temperature sensor 2 3, which is arranged on the seat cushion of the passenger seat and indicates that the inner side is used to detect the temperature of the contact area between the person and the seat cushion. The output end of the controller 1 is also connected with at least one fan arranged in the seat cushion of the passenger seat for cooling the contact area between the human body and the seat cushion. Fan six 10, fan five 9 and fan six 10 are respectively connected to the output end of the controller 1 . The controller 1 receives the detection signal of the pressure sensor 4 for judgment and receives the detected temperature of the temperature sensor 2 for processing and judgment when it is judged that the pressure of the seat cushion is greater than the upper limit of the pressure. The controller 1 determines that the detected temperature is greater than or equal to the upper limit of the temperature to control the fan Action to cool down, the controller 1 determines that the detected temperature drops to the lower temperature limit and controls the fan to stop the action; the controller 1 determines that the pad must be under pressure and receives the detected temperature of the temperature sensor 2 for processing and judgment, and the controller 1 determines that the detected temperature is greater than It is equal to the temperature upper limit value to control the fan in the seat cushion to cool down, the controller 1 judges that the detected temperature falls to the temperature lower limit value and controls the fan in the seat cushion to stop the action.

The front surface of the passenger seat back and the upper surface of the passenger seat cushion are respectively provided with a plurality of ventilation holes, and the passenger seat back and the passenger seat cushion do not have a plurality of air holes. When the device is in the working state, the pressure sensor 4 detects that the pressure on the seat cushion of the passenger is small, and the controller 1 receives the detection signal sent by the pressure sensor 4 in real time and performs judgment processing. When there is someone on the seat, the seat cushion of the passenger seat will be under a certain pressure. At this time, the controller 1 judges that the pressure on the cushion is greater than the upper limit of the pressure by receiving the detection signal sent by the pressure sensor 4. At this time, the controller 1 starts to receive the temperature The detected temperatures sent by the first sensor 2 and the second temperature sensor 3 are processed and judged respectively. The controller 1 always keeps receiving the detected temperature sent by the first temperature sensor 2 and the second temperature sensor 3 when the seat cushion is under pressure. The temperature upper limit value preset by the controller 1 is preferably $37C^0$, and the temperature lower limit value is preferably $25C^0$.

The controller 1 compares the detected temperature sent by the current temperature sensor-2 with the temperature upper limit value. When the detected temperature is greater than or equal to the temperature upper limit value, it indicates that the contact area between the person and the seat back will feel stuffy. At this time, the controller 1 sends the control signal is given to fan 1, fan 2 6, fan 3 7 and fan 4 8. Fan 1, fan 2 6, fan 3 7 and fan 4 8 start to rotate and blow air against the front surface of the backrest of the passenger seat respectively. The air flow to the front surface of the seat back through the seat back vents cools and ventilates the passenger seat back, thereby cooling and ventilating the area where the person is in contact with the passenger seat back. into the wind. Fan 1, Fan 2 6, Fan 3 7, and Fan 4 8 rectangles placed in the same plane are directed toward the front surface of the passenger seat back. During this process, the controller 1 - directly receives the detected temperature sent by the temperature sensor 1 2. When the controller 1 judges that the detected temperature sent by the temperature sensor 1 2 reaches the lower temperature limit, the controller 1 controls the fan 1, the fan 2 6, Fan three 7 and fan four 8 stop cooling at the same time, because the detected temperature reaches the lower limit of temperature, that is, when the temperature of the area where the person and the back of the passenger seat contact is equal to the lower temperature limit, the temperature of the area where the person and the back of the passenger seat is in contact has already been reached. The most comfortable temperature is reached. When the temperature sent by the temperature sensor 1 2 rises to the upper temperature limit again, the controller 1 lowers the temperature again.

The controller 1 compares the detected temperature sent by the current temperature sensor 2 3 with the temperature upper limit value. When the detected temperature is greater than or equal to the temperature upper limit value, it indicates that the contact area between the person and the seat cushion will feel stuffy. At this time, the controller 1 sends the control signal is sent to the fan five 9 and the fan six 10, the fan five 9 and the fan six 10 start to rotate and blow air against the upper surface of the passenger seat cushion respectively, and the wind blown by the fan flows to the upper surface of the seat cushion through the ventilation holes of the seat cushion for cooling. At the same time, the passenger seat cushion is also ventilated, to cool and ventilate the area in contact with the passenger seat cushion. The fifth fan 9 and the sixth fan 10 are arranged side by side with the blowing direction facing the upper surface of the seat cushion of the passenger seat. During this process, the controller 1 directly receives the detected temperature sent by the temperature sensor 2 3. When the controller 1 determines that the detected temperature sent by the temperature sensor 2 3 reaches the lower temperature limit, the controller 1 controls the fan five 9 and the fan six 10 At the same time, stop cooling, because the detected temperature reaches the lower temperature limit, that is, when the temperature of the area in contact with the passenger seat cushion is equal to the lower temperature limit, the temperature of the area in contact with the passenger seat cushion has reached the most comfortable temperature for the human body. temperature. When the temperature sent by the second temperature sensor 3 rises to the upper temperature limit again, the controller 1 lowers the temperature again.

When controller 1 judges that the detected temperature sent by temperature sensor one 2 is less than the temperature upper limit value, controller 1 does not control fan one, fan two 6, fan three 7 and fan four 8 actions; controller 1 judges that the temperature sensor three 3 sends When the detected temperature is lower than the upper temperature limit, the controller 1 does not control the action of the fan five 9 and the fan six 10 . Above, the premise that the controller 1 receives the detected temperature sent by the temperature sensor 1 2 and the temperature sensor E3 is that the controller 1 judges that the pressure on the seat cushion of the passenger seat is greater than the upper pressure limit. When the detected temperature is greater than the upper temperature limit, the controller 1 controls the fan to cool down, because people feel stuffy when the temperature is greater than the upper temperature limit. When the detected temperature is lower than the lower temperature limit, the controller 1 controls the fan to stop cooling, because the temperature reaches the most comfortable temperature for people, and when the detected temperature is between the upper temperature limit and the lower temperature limit, people will not feel it. It is extremely hot, so there is no cooling down.

When people do not need the device to work automatically, the device can also be turned off through the main switch 13. According to people's own temperature needs, the temperature upper limit value can be adjusted through the temperature setting button one 11 and the temperature lower limit value can be adjusted through the temperature setting button two 12.

When the device is turned on, it can automatically determine whether the pressure of someone sitting on the seat cushion of the passenger seat and whether the temperature of the area where the person and the passenger seat are released is higher than the upper temperature limit, and automatically determine whether the cooling action needs to be performed. Therefore, if the device is kept in the open state, the device can automatically cool down the passenger seat when it needs to cool down and does not require manual operation every time to start the cooling, reducing the trouble of manual operation. It will stop working after reaching the lower limit of temperature, that is, the optimum temperature, to save electricity, so the device has high practicability.

3.5 Advantages of the device

1. The utility model can automatically and quickly cool down the passenger seat when the temperature of the contact part between the person and the passenger seat is too high and reduce the temperature to a comfortable temperature for the human body, without manual operation every time.

2. The device can manually adjust the temperature that needs to be lowered and the temperature that the controller needs to control the fan to start and cool down, so the device of the present invention is humanized and has better practicability.

Figure 3.2 is a schematic diagram of a seat with temperature adjustment

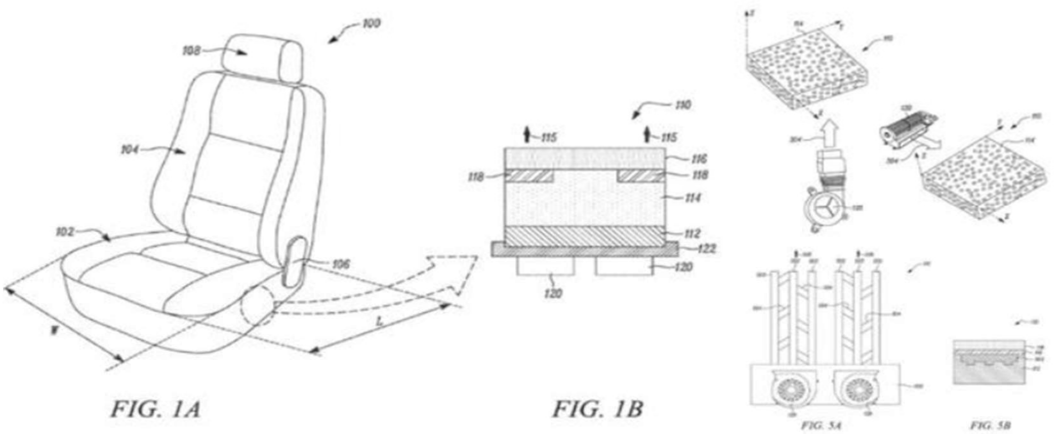

Figure 3.2. Schematic diagram of a seat with temperature adjustment

Conclusion to part 3

In the design of the temperature adjustment seat system, we mainly consider the cooling method, the control method, the automatic opening, and the upper and lower limits of the temperature.

On the cooling device, we chose the maximum number of fans to facilitate the rapid cooling of passengers.

In terms of seat material selection, choose seats with ventilation holes to make passengers feel comfortable.

Finally, based on safety, the system is equipped with a master switch, which is convenient for passengers to turn off the device in time when they are not needed or in the face of emergencies.

GENERAL CONCLUSION

In this paper, the preliminary design of the aircraft and temperature adjustment seat system are carried out.

Taking the mainstream of regional jets in the current market as a reference, we have designed a 189-seat mid-range civil airliner. The geometry and design of the various parts of the aircraft wing (length, sweep angle, aileron, etc.) were selected and calculated.

A low-level wing design with a sweep angle is adopted. To achieve good aerodynamic performance of the aircraft wing, we decided to adopt slotted flaps and midspan airfoils.

The fuselage layout is mainly divided into economy class and business class. Among them, the width of the corridor and the arrangement and spacing of the seats are selected through calculation.

As for the aircraft's center of gravity and landing gear. We use the most classic first three-point landing gear to ensure the safety of take-off and landing. We also calculated the center of gravity under various conditions (full-load take-off, landing, etc.).

In the design of the temperature adjustment seat system, we mainly consider the cooling method, the control method, the automatic opening, and the upper and lower limits of the temperature.

On the cooling device, we chose the maximum number of fans to facilitate the rapid cooling of passengers.

In terms of seat material selection, choose seats with ventilation holes to make passengers feel comfortable.

Finally, based on safety, the system is equipped with a master switch, which is convenient for passengers to turn off the device in time when they are not needed or in the face of emergencies.

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Appendix A

INITIAL DATA AND SELECTED PARAMETERS

Passenger Number	189
Flight Crew Number	2
Flight Attendant or Load Master Number	5
Mass of Operational Items	1645.92 kg
Payload Mass	19750.50kg
Cruising Speed	820.0 km/h
Cruising Mach Number	0.7653
Design Altitude	10.60 km
Flight Range with Maximum Payload	4000 km
Runway Length for the Base Aerodrome	2.20 km
Engine Number	2
Thrust-to-weight Ratio in N/kg	2.4700
Pressure Ratio	33.00
Accepted Bypass Ratio	6.00
Optimal Bypass Ratio	6.00
Fuel-to-weight Ratio	0.1900
Aspect Ratio	9.46
Taper Ratio	3.00
Mean Thickness Ratio	0.122
Wing Sweepback at Quarter of Chord	25.0°
High-lift Device Coefficient	1.050
Relative Area of Wing Extensions	0.040
Wing Airfoil Type	supercritical
Winglets	yes
Spoilers	yes
Fuselage Diameter	3.76m
Fineness Ratio of the fuselage	11.00
Horizontal Tail Sweep Angle	30.0°
Vertical Tail Sweep Angle	35.0°

CALCULATION RESULTS

Optimal Lift Coefficient in the Design Cruising Flight Point	Cy=0.43704
Induce Drag Coefficient	Cx = 0.00922

ESTIMATION OF THE COEFFICIENT $D_m = M_{critical} - M_{cruise}$

Cruising Mach Number	0.76534
Wave Drag Mach Number	
Calculated Parameter D_m	0.00542

Wing Loading in kPa (for Gross Wing Area)

At Takeoff	4.962
At Middle of Cruising Flight	4.340
At the Beginning of Cruising Flight	4.782

Drag Coefficient of the Fuselage and Nacelles	0.00810
Drag Coefficient of the Wing and Tail Unit	0.00923

Drag Coefficient of the Airplane:

At the Beginning of Cruising Flight	0.02865
At Middle of Cruising Flight	0.02771
Mean Lift Coefficient for the Ceiling Flight	0.43704
Mean Lift-to-drag Ratio	15.77206
Landing Lift Coefficient	1.676
Landing Lift Coefficient (at Stall Speed)	2.514
Takeoff Lift Coefficient (at Stall Speed)	2.074
Lift-off Lift Coefficient	1.514
Thrust-to-weight Ratio at the Beginning of Cruising Flight	0.593
Start Thrust-to-weight Ratio for Cruising Flight	2.410
Start Thrust-to-weight Ratio for Safe Takeoff	3.161
Design Thrust-to-weight Ratio Ro	3.319
Ratio $D_r = R_{cruise} / R_{takeoff}$ Dr	0.763

SPECIFIC FUEL CONSUMPTIONS (in kg/kN*h):

Takeoff	34.2956
Cruising Flight	56.2359
Mean cruising for Given Range	60.3991

FUEL WEIGHT FRACTIONS:

Fuel Reserve	0.03447
Block Fuel	0.20667

WEIGHT FRACTIONS FOR PRINCIPAL ITEMS:

Wing	0.11767
Horizontal Tail	0.01216
Vertical Tail	0.001200
Landing Gear	0.04088
Power Plant	0.10032
Fuselage	0.09657
Equipment and Flight Control	0.13428
Additional Equipment	0.00221
Operational Items	0.01868
Fuel	0.24114
Payload	0.22418

Airplane Takeoff Weight	M =88102kg
Takeoff Thrust Required of the Engine	146.19kN

Air Conditioning and Anti-icing Equipment Weight Fraction	0.0223
Passenger Equipment Weight Fraction (or Cargo Cabin Equipment)	0.0173
Interior Panels and Thermal/Acoustic Blanketing Weight Fraction	0.0071
Furnishing Equipment Weight Fraction	0.0144
Flight Control Weight Fraction	0.0061
Hydraulic System Weight Fraction	0.0170
Electrical Equipment Weight Fraction	0.0320
Radar Weight Fraction	0.0031
Navigation Equipment Weight Fraction	0.0046
Radio Communication Equipment Weight Fraction	0.0023
Instrument Equipment Weight Fraction	0.0054
Fuel System Weight Fraction	0.0071

Additional Equipment:

Equipment for Container Loading	0.0000
No typical Equipment Weight Fraction(Build-in Test Equipment for Fault Diagnosis Additional Equipment of Passenger Cabin)	0.0022

TAKEOFF DISTANCE PARAMETERS

Airplane Lift-off Speed	260.58km/h
Acceleration during Takeoff Run	2.63m/s^2
Airplane Takeoff Run Distance	992m
Airborne Takeoff Distance	578m
Takeoff Distance	1570m

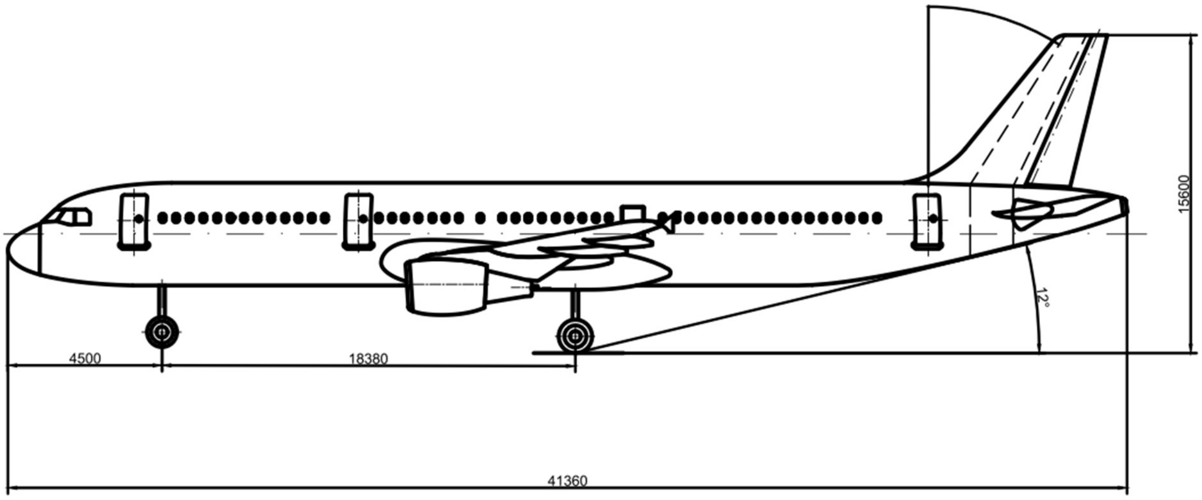
CONTINUED TAKEOFF DISTANCE PARAMETERS

Decision Speed	247.55 km/h
Mean Acceleration for Continued Takeoff on Wet Runway	0.39m/s^2
Takeoff Run Distance for Continued Takeoff on Wet Runway	1543.03m
Continued Takeoff Distance	2121.41m
Runway Length Required for Rejected Takeoff	2196.08m

LANDING DISTANCE PARAMETERS

Airplane Maximum Landing Weight	73936kg
Time for Descent from Flight Level till Aerodrome Traffic Circuit Flight	21.4min
Descent Distance	48.72km
Approach Speed	243.97km
Mean Vertical Speed	1.98m/s
Airborne Landing Distance	515m
Landing Speed	228.97km/h
Landing run distance	707m
Landing Distance	1222m
Runway Length Required for Regular Aerodrome	2040m
Runway Length Required for Alternate Aerodrome	1735m

Appendix B



Aircraft general view