МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
КАФЕДРА КОНСТРУКЦІЇ ЛІТАЛЬНИХ АПАРАТІВ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри, д.т.н., проф.
___________ Сергій ІГНАТОВИЧ
«____» ____________ 2021 р.

ДИПЛОМНА РОБОТА
ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ «МАГІСТР»
ЗІ СПЕЦІАЛЬНОСТІ:
«АВІАЦІЙНА ТА РАКЕТНО-КОСМІЧНА ТЕХНІКА»

Тема: «Пасажирське крісло ближньо-магістрального літака»

Виконавець: __________ **Антон ЗОЗУЛЯ**

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Київ 2021

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
DEPARTMENT OF AIRCRAFT DESIGN

PERMISSION TO DEFEND
Head of the department,
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«___» _______________ 2021

MASTER DEGREE THESIS
ON SPECIALITY
"AVIATION AND AEROSPACE TECHNOLOGIES "

Topic: "Passenger seat design for a short range passenger aircraft"

Fulfilled by: ___________ **Anton ZOZULIA**

Supervisor:
PhD, associate professor ____________ **Tetiana MASLAK**

Labor protection advisor:
PhD, associate professor ____________ **Victoria KOVALENKO**

Environmental protection adviser:
Dr. of Sc., professor ____________ **Tamara DUDAR**

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Kyiv 2021

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Аерокосмічний факультет
Кафедра конструкції літальних апаратів
Освітній ступінь «Магістр»
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

ЗОЗУЛІ АНТОНА ІГОРОВИЧА

1. Тема роботи: «Пасажирське крісло ближньо-магістрального літака», затверджена наказом ректора від 8 жовтня 2021 року № 2173/ст.
2. Термін виконання роботи: з 11 жовтня 2021 р. по 31 грудня 2021 р.
3. Вихідні дані до роботи: 50 пасажирів, дальність польоту з максимальним комерційним навантаженням 1200 км, крейсерська швидкість польоту 500 км/год, висота польоту 6,5 км.
4. Зміст пояснювальної записки: вибір та обґрунтування схеми літака, вихідних даних, вибір двигуна, компонування літака, розрахунок центрування спорядженого літака, проектування пасажирського крісла.
5. Перелік обов’язкового графічного (ілюстративного) матеріалу: креслення загального виду пасажирського літака, компонувальне креслення, складальне креслення пасажирського крісла літака.

6. Календарний план-графік:

№	Завдання	Термін виконання	Відмітка про виконання
1	Огляд літератури за проблематикою роботи, аналіз літаків прототипів	11.10.2021–13.10.2021	
2	Розрахунок геометричних параметрів проектованого літака	14.10.2021–20.10.2021	
3	Розрахунок центрування літака	21.10.2021–24.10.2021	
4	Проектування пасажирського крісла для ближньо-магістрального літака	25.10.2021–15.11.2021	
5	Виконання частин, присвячених охороні навколишнього середовища та охорони праці.	16.11.2021–21.11.2021	
6	Підготовка ілюстративного матеріалу, написання пояснювальної записки.	22.11.2021–29.11.2021	
7	Перевірка, редагування та виправлення пояснювальної записки.	30.11.2021–31.12.2021	

7. Консультанти з окремих розділів:

Розділ	Консультант	Дата, підпис	
		Завдання видав	Завдання прийняв
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Охорона навколишнього середовища	д.т.н, професор Тамара ДУДАР		

8. Дата видачі завдання: 8 жовтня 2021 року

Керівник дипломної роботи ____________ Тетяна МАСЛАК

Завдання прийняв до виконання ____________ Антон Зозуля

NATIONAL AVIATION UNIVERSITY

Aerospace Faculty
Department of Aircraft Design
Educational Degree «Master»
Specialty 134 «Aviation and Aerospace Technologies»
Educational Professional Program «Aircraft Equipment»

APPROVED BY
Head of Department,
Dr. Sc., professor
________ Sergiy IGNATOVYCH
«___» ________________ 2021

TASK

for the master degree thesis

Anton ZOZULIA

1. Topic: « Passenger seat design for a short range passenger aircraft », approved by the Rector's order № 2173/ст from 8 October 2021.

2. Period of work: since 11 October 2021 till 31 December 2021.

3. Initial data: passenger capacity is 50 passengers, flight range with maximum number of passengers 1200 km, cruise speed 500 km / h, flight altitude 6,5 km.

4. Content of the explanatory note: selection of the design parameters, preliminary design of the aircraft – geometry calculation and fuselage layout, centre of gravity calculations, engine selection, conceptual design of passenger seat.

5. List of mandatory graphic (illustrative) material: general view drawing of a passenger aircraft, assembly drawing of a passenger seat of a short-range aircraft.

6. Thesis schedule:

№	Task	Time limits	Done
1	Literature review, analysis of prototypes.	11.10.2021–13.10.2021	
2	Preliminary design of the aircraft: geometry calculation of the main parts of the aircraft	14.10.2021–20.10.2021	
3	Centre of gravity calculations	21.10.2021–24.10.2021	
4	Passenger seat design	25.10.2021–15.11.2021	
5	Performing the parts, devoted to environmental and labor protection.	16.11.2021–21.11.2021	
6	Preparation of illustrative material, writing the report.	22.11.2021–29.11.2021	
7	Explanatory note checking, editing and correction.	30.11.2021–31.12.2021	

7. Special chapter advisers:

Chapter	Adviser	Date, signature	
		Task issued	Task received
Labor protection	PhD, associate professor Victoria KOVALENKO		
Environmental protection	Dr. of Sc., professor Tamara DUDAR		

8. Date of issue of the task: 8 October 2021 year

Supervisor: ____________ Tetiana MASLAK

Student: ____________ Anton ZOZULIA

РЕФЕРАТ

Пояснювальна записка дипломної роботи магістра «Пасажирське крісло ближньо-магістрального літака»:

79 с., 30 рис., 9 табл., 11 джерел

Дипломна робота присвячена розробці аванпроекту ближньомагістрального пасажирського літака для авіакомпаній, які відповідають міжнародним стандартам польотів, безпечним, ефективним та надійним можливостям перевезення пасажирів, а також розробці механізмів безпеки пасажирів у надзвичайних ситуаціях.

Практичне значення результатів магістерської роботи полягає у підвищенні аварійної надійності та безпеки пасажирів на борту літака, їх комфортного розміщення в салоні.

Матеріали магістерської роботи можуть бути використані в навчальному процесі та практичній діяльності конструкторів професійних проектних установ.

Дипломна робота, аванпроєкт літака, компонування, центрування, проектування пасажирського крісла, амортизаційна опора крісла

ABSTRACT

Master degree thesis "Passenger seat design for a short range passenger aircraft"

79 pages, 30 figures, 9 tables, 11 references

Diploma work is devoted to the development of a passenger seat design for a short-range aircraft for international airlines according to the stendarts of flights, safe, effective and reliable possibilities of carrying passengers, and development of mechanism to improve the safety of passengers in emergency situation.

The practical value of the master's degree work is the increase of emergency reliability and safety of passengers on board, their comfortable accommodation in the passenger compartment.

The materials of the master's diploma could be useful for the educational study and it could be implemented in the aviation industry – airliners, manufacturers of passenger seats.

Master thesis, preliminary design, cabin layout, center of gravity calculation, passenger seat design, shock-absorbing support of a seat

CONTENT

INTRODUCTION

Airlines are paying more attention to the passenger comfort, cabin optimization and increased number of passengers in the economy class accommodation. Economy class comfort of single aisle low cost flight is very much differ from the wide body, long-haul flight. The new demands for the passenger's seats for the short haul flight are the USB port and PED holder, tablet holders, Wi-Fi on board. And the seat back recline becomes not necessary convenience for the short flight till 3 or 4 flight hours, we come to pre-recline seats, new design and ergonomic innovations of the seat structure provide comfort position of occupants, especially for slipping. The ergonomic pressure distribution on the seat structure, reduced width of the backrest and cushions, guests enjoy the flight with even more personal volume.

New demands in passenger service are the tasks for the aircraft designers, manufacturers and airliners. Even such improvements as soft goods, pillows and blankets, LED lighting, type of materials of surrounding items and hygienic surfaces or smart fabric are required.

Despite of new trends in the conveniences for the aircraft seat design, for the aviation industry the flight safety is the main goal for all consumers of it. The safety of passengers in the emergencies is the key requirements for the HIC tests of the seats. The huge acceleration is expected during landing strike, so the airframe of the seat has to withstand the vertical loads and reduce the loads on occupants.

So, the aim of the presented diploma work for the master degree is the conceptual design of the passenger seat for economy class cabin with the possibility to absorb the landing shock by the special energy absorbing design and special attachment of passenger seat to the floor.

PART 1. AIRCRAFT SEAT AS THE MAIN FACTOR AFFECTING PASSENGER COMFORT

1.1 General requirements for the passenger seats of an aircraft

One of the main requirement to any part of the aircraft is the minimum mass at maximum strength. This requirement is actual not only for the wing structure or frames of the fuselage, it also significant task for the passenger seat.

The general requirements for passenger seats include strength, reliability, availability of special attachment points to the floor of the aircraft fuselage, minimum weight of the product, incombustibility (seat cushions made of foam rubber should be covered with a non-combustible fabric), the presence of seat belts.

Part 25 of the FAR, section 25.785. "Seats, berths, seat belts and harness systems" - contains special requirements for passenger seats in aircraft.

Every persons who has reached the age of two, a chair (or a sleeping place for a person unable to move) should be provided. Each seat, berth, waist harness, harness system and adjacent aircraft parts in each seat intended to accommodate persons during take-off and landing must be designed so that a person using these aids correctly will not be seriously injured in an emergency landing as a result of the action of inertial forces specified in paragraphs 25.561 and 25.562 of FAR.

Each chair or berth must be of an approved type. Everyone, sitting in a chair that’s set at an angle of more than 18° to the vertical plane passing through the longitudinal axis of the aircraft, must be protected from head injury by a safety belts and energy-absorbing supports, supporting the arms, shoulders, head and spine, or by a waist; and shoulder harness, preventing head contact with any traumatic object.

Everyone seated in any other seat must be protected from head injury with safety belts in one or more of the following ways:

- shoulder harness straps have to prevent head contact with any traumatic object.
- by shifting any injurious object outside the head's movement radius.
- an energy-absorbing support that supports arms, shoulders, head and spine.

Every front seat should be planned so the front end has a cushioned seatback and headrest, the airframe support are competent to endure the static response power from an individual, exposed to the forward greatest speed increase. The front seats in business class and in the top notch ought not to have corners and jutting parts, which in crisis circumstance can harm the individual situated in the seat. Each seat and its design, every seat straps and their connection should be developed for an individual with mass 77 kg, considering the breaking point load factor, inertial powers and responses between people, seat, seat straps and wellbeing bridle for every system of flight, during the arrival, during the slowing down and even crisis landing conditions. When calculating the strength and testing of seats, safety berths and the seat airframe structure, it can be assumed that the ultimate loads in the directions forward and backward, sideways, downward and upward act separately or use the combinations of some case of loading if the required strength is confirmed in each of the specified directions.

But travelers situates every traveler lodge needs to oblige the seats for flight participation, where they must be situated during take-off and arriving, as needed by methods of working guidelines. The seat for swaggers should be situated close to the emergency exit at floor level or another area is adequate on the off chance that it further develops the traveler’s emergency. An airline steward seat ought to be situated close to crisis exits; it very well may be type A or Type B. Different seats for airline stewards could be dispersed near the emergency exits at floor level or in the galleys close to the help entryways or in passageways. The place of the seats needs to give a decent view in the traveler compartment region for which they are capable. Their seat does not need to cloud for travelers the use of paths or ways out, when it in shut state. It likewise does not be the article for hit by travelers or gear.

The seats of flight attendant are mounted towards or opposite the direction of flight, are equipped with seat back made from energy-absorbing materials to provide comfort for arms, shoulders, head and spine. It has harness system equipped of four straps - two for shoulders support and safety belt with a single-point opening mechanism. Each waist straps must be equipped with a locking device with metal contacting elements.

During the passenger or pilot seat design, it is necessary to solve several problems:

- to provide necessary geometric parameters due to the cross-section of the passenger cabin or the cockpit of pilot;
- to ensure the strength characteristics of the seat structure and its attachment to the floor;
- to provide head injury criteria, safety characteristics (correct distance between seats, seat pitch, energy-absorbing materials, the forces in the safety belts and shoulder harness system, loads on the spine and lumber and hands).

In reality, the process of creating a new chair takes place in several stages:

- development of the conceptual seat design, providing the necessary geometric parameters;
- development of the digital human modeling (DHM) systems for virtually design - antromorphic test dummy (ATD) in a block of seats;
- simulation of the static and dynamic tests of DHM for checking the requirements of injury safety, head injury criteria (HIC);
- experimental full-scale testing of the ATD for the measurement of HIC criteria, evaluation comfort for passengers and crew members;
- experimental test of the materials used for fire safety and toxicity;
- obtaining approving documents for the use of this type of seats on samples of aviation equipment.

The material nature of the front seats should be appropriate for the working conditions, and the tests should give their appropriateness. In the assembling of seats, the most present day advances in the avionics business are utilized. All underlying components should be secured to forestall weakening or loss of solidarity in help, consumption, wear or different variables. Covers and other outside materials which are utilized in the development of seats should be fireproof as per security necessities.

During deciding of the ergonomic necessities, one should to be considered that the flight seat is where the conditions for the action of the group individuals are shaped, the movement and comfort of seating are for travelers.

1.2. New trends in the passenger seat comfort

Aircraft seat is one of the main factors affecting passenger comfort the challenge is to design a lightweight aircraft seat without compromising on comfort.

Passenger seats contribute to the weight of aircraft passenger equipment. To receive fuel efficiency of the aircraft, to save the tickets cost, the lightweight materials are preferred for the seat construction, for the interior decorative panels and furnishing of the passenger compartment.

Studies by indicate that increasing the contact area between human body (passenger) and seat can have a positive effect on comfort. This might be achievable by a seat that follows the human contour.

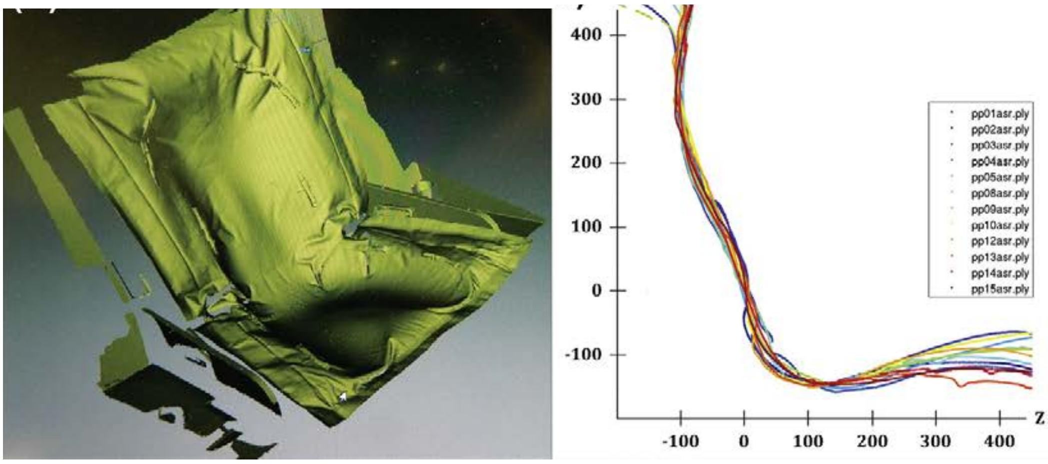
In a new trend in the seat design by the exploring the foam in the backrest of a seat by designing a back shell based on the human body contour has been presented.

As sleep is one of the most conducted activities on both short-haul and long haul flights, so this condition was taken for the simulation. Three different types of aircraft seats were studied (fig.3.1): Sitting was contemplated in project EC, while a horizontal dozing movement was considered in project PEC and full level dozing, just as dynamic and detached sitting exercises were examined in project BC, depicted in the work.

a) b)

Fig. 3.1 - Setup for economy class seat project: wooden frame with “seat row” in the front to simulate legroom (a); setup for premium economy and business class projects (b).

The applying three-dimensional (3D) scanning methods (fig.3.2) determine the ideal seat contour following the human body. These tools are widely used in ergonomics, biomechanics, industry, medicine, and animation for different approaches.



a) b)

Fig. 3.2 - Scanning process for Project EC, from left to right: a - 3D scanning the body imprint; b- virtual 3D surface of the imprint; (C) best-fit profile of the superimposed contour scans (each line represents one participant).

After the scanning of the participant's position in the seat, their most aft and most forward position under the deflection of seat back (deflection of data at fig. 3.3 a), also the differences in the position of 95% male and 5% female (fig.3.3.b), the best frame for the seat was designed.

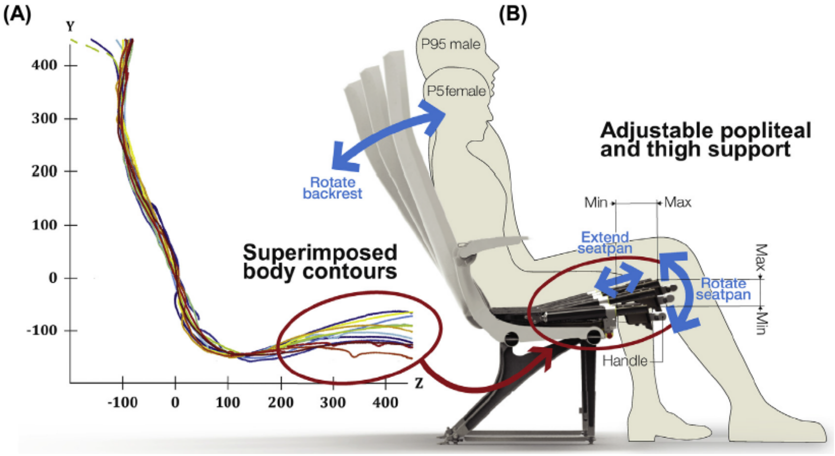


Fig. 3.3 - Body contour for project:

a) different positions of the body for all participants;

b) adjustable seat back position and seat cushion position to provide optimum support for both short and tall passengers.

The final results of the presented investigation – is the best fit design of the passenger seat, which provide more comfortable position for passengers in a seat (fig.3.4) and in a case of full-flat “bad” position.

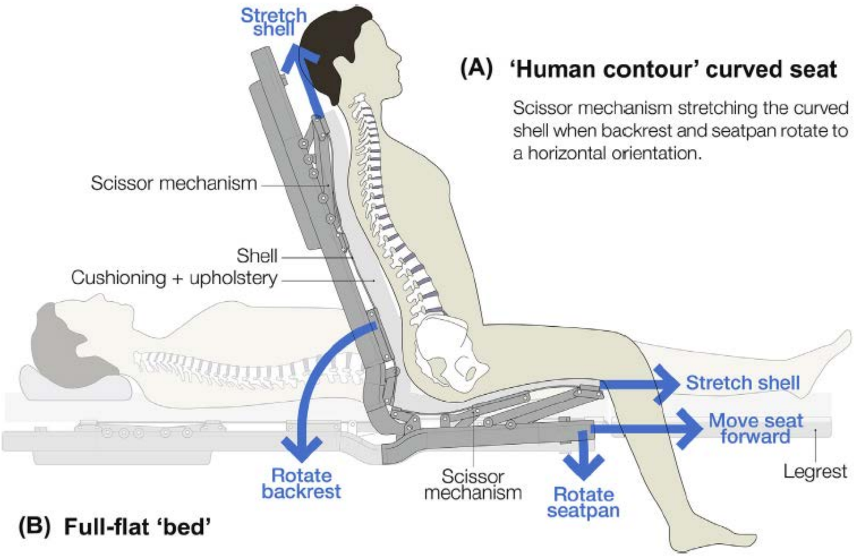


Fig. 3.4 - Full flat sleeping design concept for business class seat

The presented trends are now at the stage of implementation, full-scale testing and certification on HIC criteria. In the nearest future, we could try it on themselves.

1.3 Safety level of an aircraft seat

In the passenger cabin of the aircraft, in front of the first row of passenger seats, there is usually some element of the interior design (partition, wardrobe, toilet, etc.), which is considered as an obstacle. At the same time, the distance between the seat and the obstacle in front should be such that the safety of the passenger is ensured, that is, the passenger should exclude contact either with the obstacle, or, in the event of possible contact of the passenger with the obstacle, an acceptable level of injury safety should be ensured. To assess the level of head injury, the HIC criterion was introduced. For a quantitative assessment of the HIC criterion, in accordance with aviation rules (FAR-25), the following formula is used:

$$HIC = (t_2 - t_1)\left\{\frac{1}{t_2 - t_1}\int_{t_1}^{t_2} a(t)dt\right\}^{2.5} \leq 1000,$$

where: t_2 - t_1 - time at which the ATD expect the maximum loads,

a(t) is the total acceleration during the impact.

However, in most cases, the justification of the compliance of the design with the requirements of the rules is carried out by means of dynamic tests.

As per momentum FAA rules, if the separation from the base place of the seat (Fig 3.5) to the divider or divider in front is no less than 42 inches (1066.8 mm) for economy seats and something like 45 inches (1143 mm) for business class situates, an adequate degree of traveler injury security is guaranteed, and there is no requirement for extraordinary dynamic tests. Nonetheless, this seat pitch is not consistently adequate for economic reasons. Thusly, the seats, which are introduced at a more limited seat pitch from the past seat back in front, and an adequate degree of injury wellbeing for travelers is guaranteed by special tests on HIC.

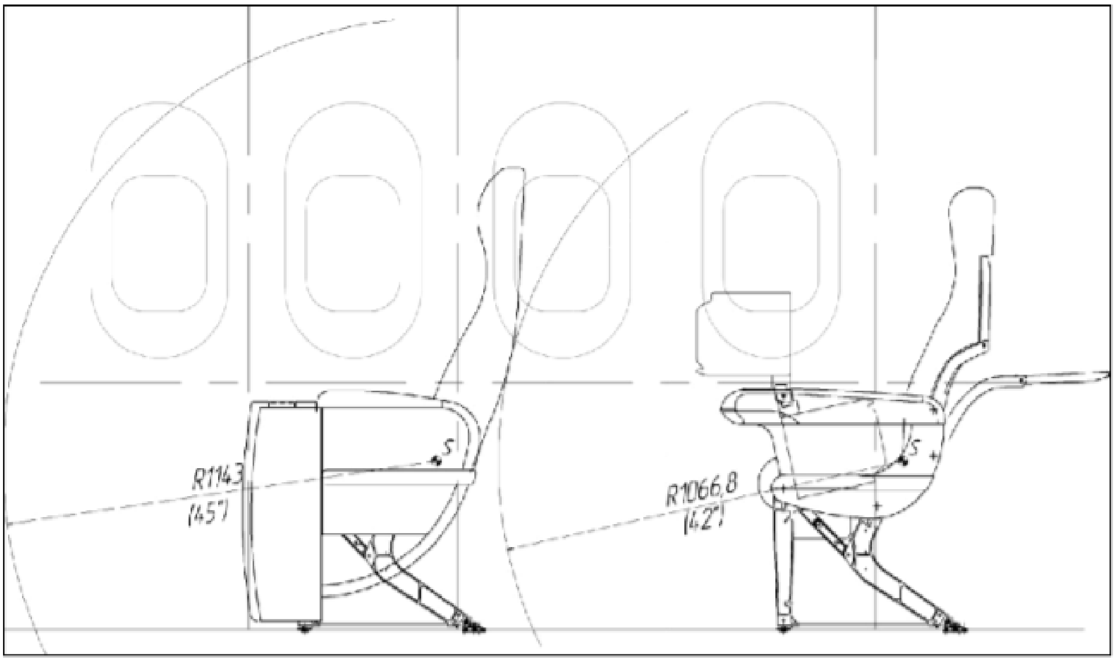


Fig. 3.5 - The distance in front of the economy and business class seats

In accordance with the layout of the aircraft under consideration (Fig.3.6), in front of the first row of passenger seats, at a distance of 624.8 mm from the attachment point of the front leg of the seat (844.9 mm from point S), there can be an obstacle, for example, the rear wall of the wardrobe, the structure of which is made in the form of a rigid reinforced three-layer panel made of composite materials.

Fig. 3.6 - Layout of the cabin of a medium-haul passenger aircraft

Since the specified distance is substantially less than 42 inches, an assessment of the injury safety of passengers seated in the first row seats is necessary.

For the assessment, we used the measurements of the parameters of the head movement of the dummy, carried out during the dynamic tests of seats and the results of studies of the influence of the stiffness of partitions on the value of the HIC parameter, described in the FAA reports. As a parameter characterizing the stiffness of the wall, in the FAA reports, the ratio of force to deflection (k) under static loading, conventionally called stiffness, was taken. The same parameter was used in the analysis of the structure of the back wall of the wardrobe. Determination of the stiffness of the zones of possible contact of the passenger's head with the wall was carried out using a finite element model and the MSC.NASTRAN software package by analogy with the methodology given in articles.

The calculation showed that the maximum stiffness coefficient of the back wall of the wardrobe was $k \approx 667$ kN / m. In both types of seats, the harness systems were used as a harness.

The documents present the results of research carried out in the impact dynamics laboratory of the National Institute for Aviation Research (NIAR) to study the influence on the HIC value of such parameters as:

- the stiffness of the obstacle in front;
- distance from the chair to the obstacle;
- the amount of overload achieved during the impact.

During the research, dynamic tests were carried out, as well as calculations were performed using the biodynamic model. The model enables dynamic and nonlinear calculation of bodies and systems consisting of several bodies using FEM. As the obstacles in front, vertically installed three-layer interior panels made of KM were used, the stiffness of which was 90-110 kN / m (500-600 lb.). The head impact angle during the tests varied over a wide range from 10 to 67 degrees. The distance to the obstacle during the tests varied in the range from 0.813 to 0.899 m (32-35 inches). The overload realized during the impact varied from 15.5 to 17.3 g. Head velocity at the moment of impact varied from 13.7 to 15.2 m / s (45 to 50 ft / s). As follows from the test results, As a result of parametric studies carried out using the biodynamic model, the dependence of the HIC value on the stiffness of the partition was obtained for seats located at a distance of 0.838 m (33 inches) and 0.889 m (35 inches) from the partition (Fig. 3.6). In this case, the speed of the head of the dummy at the moment of impact varied from 12 to 15 m / s. Since the unbending nature of the back mass of the closet of the airplane viable is $k \approx 667$ kN/m, the head velocity at the moment of impact on the back divider, gotten from handling the aftereffects of dynamic test of economy class seats, is around 15 m/s, and the distance to it from the armchairs 925 mm, then, at that point, from the investigation of the conditions displayed in Fig. 3. It very well may be seen that the HIC worth will significantly exceed the admissible worth of 1000 units. Therefore, it is necessary to provide for some additional measures to ensure the required level of injury safety. Let us consider the influence of the obstacle stiffness and the parameters of the passenger's head movement on the value of the interaction effort between the head and the obstacle during the impact, and hence on the value of the HIC parameter. Speed V_f of head movement (the component of the velocity normal to the obstacle) at the moment of contact with the obstacle determines the amount of kinetic energy of the head spent on deformation of the obstacle at the moment of impact. This energy in the process of impact is converted into potential energy of deformation of the obstacle and is equal to the work expended on the deformation of the obstacle. How much this work can be represented as:

$$\frac{mV_{\phi}^{2}}{2} = \int_{0}^{\Delta\omega} F(\omega)d\omega,$$

where: F (ω) - the effort of interaction between the head and the obstacle during the impact;

m- is the mass of the mannequin's head;

w- is the deflection of the structure.

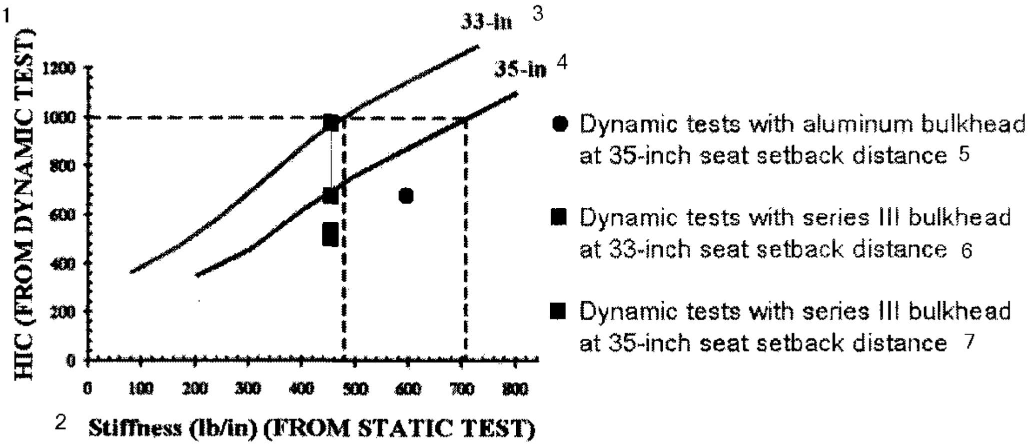


Fig.3.6 - Dependence of the HIC value on the stiffness of the partition

The amount of deflection w of the obstacle from the impact of the head depends on the compliance of the obstacle in the direction of impact. The more compliance, the less the amount of force of interaction between the head of the dummy and the obstacle, and vice versa. In fig. 3.7 schematically shows the work (the area under the graphs of the function F = f (ω) spent on deformation of the obstacle for two values of the obstacle stiffness k_1 and k_2 ($k_1 > k_2$) at the same kinetic energy of the head at the moment of impact

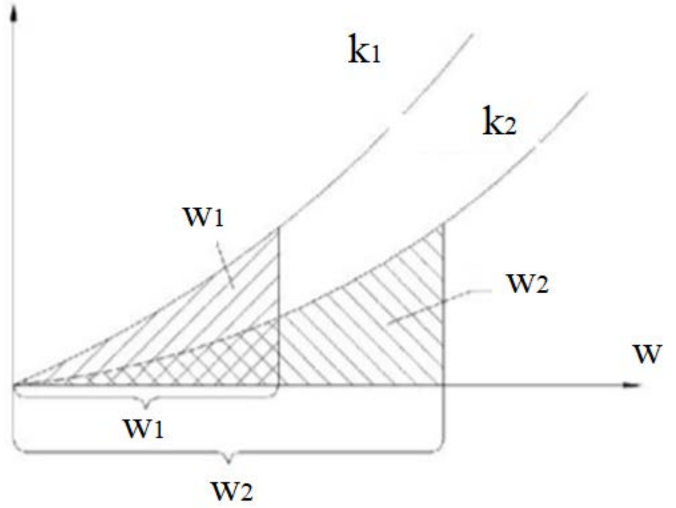


Fig. 3.7 - Work spent on deformation of the barrier

The work depends on the interaction force and the amount of deflection, and the shape of the obstacle is a minor factor and can only affect the local distribution of the force in the contact zone. Thus, the stiffness of the obstacle in the direction of head movement and the speed of the head at the moment of impact are the main parameters that affect the magnitude of the force of interaction between the head and the obstacle. Since the work of deformation is the product of force and path (deflection), then for the same kinetic energy of impact, the frontal component of the head acceleration for an obstacle with rigidity k_1 will be greater than for an obstacle with rigidity k_2. Therefore, since the head acceleration a(t) appears directly in the formula for calculating HIC; the HIC value for an obstacle with a lower stiffness k_2 will be less. Evaluation of the force F_x of the interaction of the head with the obstacle can be performed as follows:

The kinetic energy of the passenger's head in the direction of the OX axis (normal to the obstacle) at the moment of impact is determined:

$$W_к = \frac{m_{головы} V_x^2}{2} .$$

2. The potential deformation energy of the barrier is determined, which is equal to the kinetic energy of the passenger's head:

$$W_{nom.} = \int_{0}^{\omega_{\max}} F(\omega) d\omega,$$

w - deflection in the direction of impact;

F(ω) - dependence of the force of interaction of the head with an obstacle on the amount of deflection.

3. The maximum effort of interaction of the head with the obstacle is determined. In the case of a nonlinear relationship between force and deflection for the considered obstacle, using numerical calculation or in the process of static tests, the deflections of the obstacle are determined for 5-6 values of the forces, after which the dependence is determined using the least squares method

$$F(\omega) = \sum_{i=0}^{n} a_i \cdot w^i$$

The maximum value of the deflection w max, and, consequently, the maximum value of the force F(ω) w , can be determined by solving the algebraic equation i+1 degree

$$\frac{m \cdot V^2}{2} = \sum_{i=0}^{n} \int_{o}^{\omega_{\max}} a_i \cdot \omega^i \cdot d\omega = \sum_{i=0}^{n} \frac{a_i \cdot \omega_{\max}^{i+1}}{i+1} .$$

If we assume a linear relationship between force and deflection, then the problem is simplified and the force is determined using the following ratios and formulas:

$$W_{\kappa} = W_{n} = k \cdot \omega^2 / 2, \Rightarrow \omega = \sqrt{\frac{2 \cdot W_{\kappa}}{k}},$$

$$F_{\omega} = k \cdot \omega .$$

The boundaries of the effect of the life sized model's head on the back mass of the closet for different distances between the seat and the back mass of the closet, just as the cooperation powers of the top of the main line traveler involving the furthest left seat in the three-seater seat of a medium-pull, not really settled as per the above technique.

HIC tests using a economy class three-seater seat, the front legs of which are set at a distance of 625 mm from the obstacle, have shown that, even when an energy-absorbing coating (foam) is applied to the impact zone, the HIC value is at least 4000 units. Such a large value of the HIC value indicates that in order to ensure an acceptable level of injury safety, it is necessary either to significantly increase the distance to the obstacle, or to reduce the rigidity of the obstacle, or to look for other ways to solve this problem.

To ensure an acceptable level of injury safety according to the HIC criterion for a first-row passenger for a medium-haul aircraft, proposed a design of seat belts with inflatable safety systems. The airbag system is a combination of the industry-standard 16g two-point aviation safety harness and an airbag retrofit of an advanced automotive airbag technology. As the powerful circumstance creates during a crisis arrival, the security framework blows up (away from the safety belt and away from the traveler to give further developed head and chest area insurance), mellow the traveler's effect, and afterward, as the traveler's head and middle moves descending, the framework discharges cushion pressure, furnishing the traveler with simple exit from the seat and airplane.

The inflatable restraint system consists of the actual inflatable cushion assembly and a gas hose attached to a manually adjustable harness. The airbag, gas hose and harness strap are all contained within a leather or fabric cover that has a tearing seam. The cover of the inflatable cushion is made to open when the gas pressure is applied, which makes it possible to deploy the inflatable cushion. The gas supply pump consists of a cylinder and a gas nozzle. The gas is directed through the gas hose to the inflatable cushion. The inert gas (helium) in the pump is non-toxic and expands at ambient temperatures. The inflatable system is not connected to the aircraft power supply system and does not have interfacing with any of the aircraft systems. The use of the safety system gives the aircraft the following advantages over conventional two-point harness systems:

- the existing load-bearing structure of the seats and the attachment points of the harness system is retained;
- the implementation of the declared layout schemes for the placement of passenger seats in the transport cabin is ensured;
- the main design of the interior in the area of the front row of seats is preserved without significant changes;
- no additional duties on the part of flight attendants and additional actions of passengers are required in comparison with traditional two-point harness systems;
- there are no operational restrictions;
- low maintenance: the system requires a diagnostic check every 1900 flight hours, which takes only a few seconds per location.

The electronics module and the gas pump must be renewed every seven years. Inflatable cushions of the safety system can have various configurations and parameters. To assess the influence of the parameters of this system on the HIC value and the choice of the type of pillows, more than a hundred experiments were carried out using various types of pillows. Experiments have shown that the value of HIC is influenced by many factors: the time of deployment of the pillow, the shape of the pillow, the relative position of the head and the pillow during impact, deformation (stiffness) of the chair, the rigidity of the obstacle in front; distance to the obstacle and many others. The deployment time of the air cushion should be such that it is completely filled, and at the moment of impact, the maximum pressure in the cushion is reached, since earlier filling will lead to gas leakage through the material and seams of the cushion, and the head of the test dummy may hit the obstacle directly through the pillow. Filling the cushion later will not allow the cushion effect to be fully exploited. At the moment of impact, the pillow should take a position close to the center of gravity of the passenger's head. The deformation of the chair during the test affects the impact zone against the obstacle in front and the speed of movement of the dummy's head at the moment of impact. The influence of the stiffness of the barrier is quite fully disclosed in the works. However, the use of seat belts with the system only made it possible to significantly reduce the value of the HIC parameter, but did not provide an acceptable level of passenger injury safety. The allowable HIC esteem was accomplished distinctly because of the utilization of safety belts with the framework related to an adjustment of the calculation of the closet divider in the space of a potential head effect of the traveler possessing the left seat in the three-seater unparalleled view block (the closet divider was extended to expand the separation from the traveler's head). The graph of the change in the parameters of the dummy's head movement (acceleration) for the case of using only the system and for the case of using the system in combination with a change in the geometry of the wardrobe wall is shown in Fig. 3.8

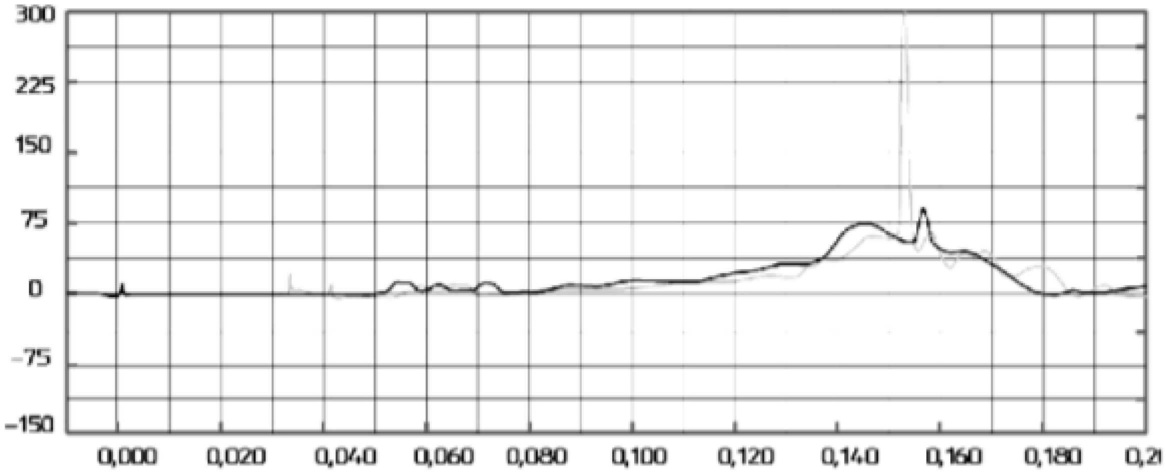


Fig. 3.8 - Graph of changes in the parameters of the manikin's head movement for the case of using only the airbag system and for the case of using the system in combination with a change in the geometry of the wardrobe wall.

Based on research and experiments carried out by protected, the parameters of the cushion (cushion response time, cushion pressure, cushion configuration) and the wardrobe wall configuration were selected for the first row of passenger seats, which made it possible to achieve a stable HIC value. Approval has been obtained for the use of wedge-shaped pillows (for passengers occupying the center and right-most seat, respectively) and barrier-type pillows (for the passenger occupying the leftmost seat in a three-seat block of seats). The wedge-shaped pillow of the type limits the movement of the body and head along the X coordinate, and at the moment of impact the head moves along a trajectory close to a circle, and the magnitude of the frontal velocity is insignificant. If a wedge-shaped harness is installed in the chair. Therefore, the value of the achieved HIC value does not exceed 600 units. A barrier-type pillow in the process of actuation takes place between the head and the obstacle, and the kinetic energy of the head is spent on deformation of the pillow (Fig. 3.9). Because the thickness of the pillow is significant, there is a gradual deceleration of the dummy's head, which ensures a small amount of acceleration of the head movement at the moment of impact.

a) b)

Fig. 3.9 – Strike of the head of test dummy with the wall and the airbag work: a) wedge-shaped pad; b) barrier type pillow.

According to the experiments, the time of contact of the head with the pillow when using only the airbag system is significantly less than when using the safety system in combination with a change in the geometry of the wardrobe wall. At the initial moment of head contact, the head is decelerated with the help of the pillow, and only then, the collision with the obstacle occurs after the pillow is deformed. The parameters of the pillow and the configuration of the wall of the wardrobe must be selected in such a way that the value of the maximum acceleration of the head is negligible, due to which an acceptable value of HIC is achieved. When using only the system, the pillow does not fully fulfill its functions. Therefore, the impact turns out to be hard, with a significant acceleration of the head and a short time of contact of the head with an obstacle, which ultimately leads to a significant level.

Conclusions to the part

New trends in the passenger comfort on aircraft board is not limited by the conveniences of the seat. It has to provide enough place for all positions of occupants, to prevent strike with any surrounding items in passenger compartment. Current requirements to the comfort are not exclude the requirements to the flight safety. To provide affective safety of passengers on board it is necessary to follow all instructions before departure, as well as to understand how to act in any emergencies – ditching, decompression, abrupt takeoff and emergency landing.

One of the main criteria to ensure the flight safety of passengers is the head injury criteria, which is more critical for the passengers of first row or passengers before the wall or class divider seats with the usage of harness systems with special airbags. Using the harness systems with airbags was determined that their use on the front row seats makes it possible to reduce the length of the transport cabin of a medium-haul passenger aircraft by 340 mm or install additional equipment. Another decision to reduce the HIC for emergency landing could be the implementation of energy-absorbing materials.

PART 2. PRELIMINARY DESIGN OF SHORT RANGE PASSENGER AIRCRAFT

2.1. Analysis of prototypes and short description of the aircraft

Selection’s of optimal parameters is straight dependent of planned aim and area of aircraft usage, economical requirements based on complicity of construction, ability to degrees the usage of some of expensive construction materials and methods of assembly, planned passenger and cargo capacity and complexity in maintenance.

Creation’s of basic aircraft outline includes aerodynamic calculation, geometrical parameters calculation and centering of equipped fuselage. These steps form the final exterior and interior appearances of a designed aircraft.

Designed’s aircraft there were chosen the prototypes in range of 50-100 passengers and middle-range of usage. Such aircraft like Xian Ma6000, Ил-114 and F28-0100 will compete with designed aircraft in chosen market segment. The performance of prototypes are presented in table 2.1.

Table 2.1 - Performances of prototypes

PARAMETER	PLAINES		
	Xian Ma600	Ил-114	F-28-0100
The purpose of airplane	Passenger	Passenger	Passenger
Crew/flight attend. persons	2/2	2/2	2/2
Maximum take-off weight, m_{tow}, kg	21800	23500	44920
Maximum payload, $m_{\text{к.max}}$, kg	5500	6500	11563
Passengers	60	60	100
The flight altitude $V_{\text{w. ек}}$, m	6500	7600	11300
Flight range $m_{\text{к. max}}$, km	1400	2000	3111
Take off distance $L_{\text{TO. d.}}$, m	1900	1700	2010
Number and type of engines	2xPW-127J	2xTB7-117CT	2xRR Tay-620
The shape of the fuselage cross-section	circular	circular	circular
Fineness ratio	8	9	10,38
Fineness ratio the nose and rear part	4	4,85	4,2
Sweepback angle at 1/4 chord line, ^{0}	6	6	20

Commonplace area of constructional components, head streamlined plans of recorded models turned into the gauge for planned airplane diagram. For design arrangement the blend of the best qualities from every one of the three models are utilized. Other than, the Xian Ma600 is picked as a primary model since it meets practically all necessities for center reach economy class traveler plane.

The plane is a cantilever high-wing monoplane with turboprop motors put on the wing and twin-cycle landing gear with a front single-strut landing stuff and two principle gears. Fuselage has circular cross-area. Empennage has a traditional design. Rudder and lifts are furnished with aerodynamic balance.

The fuselage has semimonocoque design. It is pressurize between the first and the fourteenth formers.

The framework of fuselage consists of 49 formers, longitudinal beams and stringers manufactured from extruded profiles, and working skin.

The cockpit, passenger cabin and all auxiliary units are located in the fuselage. There is a cargo bay behind the cockpit on the lower part of the fuselage, in front of which located a large cargo hatch. In the non-pressurize nose compartment (up to the first frame) the units of radio equipment are located. The explorer hold up is confined of the rest compartments by the bulkhead. In the tail area there is a section passage, a sideboard with a flight attendant's seat, a lavatory and wardrobe. At the rear of the compartment is the capacity compartment. On the left side is the passenger front door with a sidewalk.

The wing of the airplane has high shape proportion and trapezoidal planform. There is a bunch of underlying components of various thickness in vertical planform of cross-area, giving great stacked drag during immaterial parasitic, great lateral stability and controllability during angles of attack.

Wing is a torsion box type. It’s divided into a center section, two middle and two detachable parts, joined along ribs with the help of fitting connections.

Wing are consist of a central (made by spars, upper and lower panels and ribs), nose and tail parts, end fairings, ailerons and slotted flaps. The wing center section consists of solid-pressed large-sized panels and spars that reduces its weight and greatly simplifies the process of assembly, and increases the reliability of the design. There are four soft fuel tanks in the torsion box of the center section of the wing. The middle parts of the wing are the sealed fuel tank.

Empennage's consists of vertical and horizontal part. Vertical tail unit includes fin and rudder, horizontal–stabilizer and elevator. In front of the fin, dorsal fin is mounted on the fuselage.

Sweep's of the vertical and horizontal tail unit is greater than the sweep of the wing, so that the aerodynamic characteristics of the tail unit with an increase in the Mach number do not deteriorate faster than the characteristics of the wing. The grater sweep of the fin is also suitable, because at the same time the horizontal stabilizer efficiency is increased due to the increase of its moment arm.

The airfoil of vertical and horizontal stabilizer is symmetrical. Symmetric airfoil allows maintaining the same character of aerodynamic loads during deflection of rudders in different directions and, in addition, has a smaller drag.

The vertical tail unit in comparison with horizontal one has an increased relative thickness of the airfoil in order to reduce the mass of fin loaded by forces, from these parts vertical and horizontal.

Design's feature of the aircraft empennage is the attachment of the assembled panels along the spars web that is provide high manufacturability of the assembly.

High performance's of control column provide aircraft controllability over the entire range of flight speeds, at all altitudes in a wide range centering's.

Landing gear's consist of three struts. All undercarriage struts are retractable. The direction of retraction is counter the flight.

The nose landing gear strut is located under the cockpit canopy. Main's landing gear struts are installed under the engine nacelles and retract in flight forward into special compartments under the engines. On a fixed axis of each main strut, two wheels with disc brakes are installed. Wheels are equipped with inertial sensors.

Landing gear struts are locked in extended and retracted positions with the mechanical locks actuated by the hydraulic cylinders.

Landing gear wheel well are closed by entryways while landing gear struts are fully extended or retracted. The doors actuation is performed by mechanisms that kinematically joined with strut actuation system. For steering has used the nose landing gear.

The actuators powered by aircraft hydraulic system perform the turn of the nose strut wheel. Besides the extension and retraction, braking, locks opening, doors actuations are performed by hydraulic system too. In case of hydraulic system failure, the retraction and extension of a landing gear can be performed with use of mechanical system. In this case, the extension of nose or main landing gear is performed partially due to their own weight.

For optimum balance of aircraft stability and contolability was chosen struts location. That is why during the calculation of wheelbase and the wheel track the centre of gravity of an aircraft should be considered.

The power plant: The Pratt & Whitney engine is a three shaft, turboprop engine. A single stage low-pressure turbine and the high-pressure compressor drive the centrifugal low-pressure impeller by a two-stage high-pressure turbine. Power is delivered to the offset propeller reduction gearbox via a third shaft, connected to a two-stage power turbine.

The operate of control system all engine functions, including power regulation. Engines PW 127H, PW 127J, PW 127B - are three-shaft, turboprop engines, in various modifications installed on passenger aircrafts Fokker 60 (PW 127B), Ил-114 (PW 127B) and transport Xian Ma600 (PW 127J).

2.2. Aircraft layout

Aircraft layout calculation is based on the selection of the purpose of the designed aircraft, its main dimensions, and operational requirements.

Design of geometry calculation of principles structural units as wing, fuselage, tail unit, and landing gear. Other than, above mentioned, this analytical part includes choice of power plant and interior scheme. The interior scheme estimation includes dimensional calculation based on aircraft capacity requirements.

This layout was implemented in line with both modern standards and wellestablished calculation methods.

2.2.1 Wing geometry calculation

Full wing area is:

$$S_w = \frac{m_0 \cdot g}{P_0}$$

where m_0 – take-off weight;

g – gravity acceleration;

P_0 – specific wing load.

Wing area:

$$S_w = \frac{20800 \cdot 9.8}{3114} = 65{,}46\ (m^2)$$

Wing span is:

$$I_w = \sqrt{S_w \cdot \lambda_w}$$

where λ_w – wing aspect ratio.

$$I_w = \sqrt{65{,}46 \cdot 11{,}38} = 27{,}3\ (m)$$

Root chord is:

$$b_0 = \frac{2S_w \cdot \eta_w}{(1+\eta_w) \cdot I_w}$$

where η_w – wing taper ratio.

$$b_0 = \frac{2 \cdot 65{,}46 \cdot 3}{(1+3) \cdot 27{,}3} = 3{,}6\ (m)$$

Tip chord is:

$$b_t = \frac{b_0}{\eta_w}$$

$$b_t = \frac{3{,}6}{3} = 1{,}2\ (m)$$

Maximum wing thickness is:

$$C_{max} = C_w \cdot b_t$$

where c_w – medium wing relative thickness.

$$C_{max} = 0{,}12 \cdot 1{,}2 = 0{,}144\ (m)$$

On board chord is:

$$b_{ob} = b_0 \cdot (1 - \frac{(\eta_w - 1) \cdot D_f}{\eta_w \cdot I_w})$$

where D_f – fuselage diameter.

$$b_{ob} = 3{,}6 \cdot \left(1 - \frac{(3-1) \cdot 2{,}9}{3 \cdot 27{,}3}\right) = 3{,}345\ (m)$$

For mean aerodynamic chord, determination the geometrical method was used (Fig. 2.1). The mathematical method infers the estimating of corresponding to the chords line which lies on the intersection of the section connecting the middles of tip and root chords with another section connecting the upper end of tip chord extension (which is equal to the length of root chord) with lower end of root chord extension (which is equal to the length of the tip chord). This method was chosen due to accuracy and simplicity in performance.

Thus, the mean aerodynamic chord is equal 2,6 m.

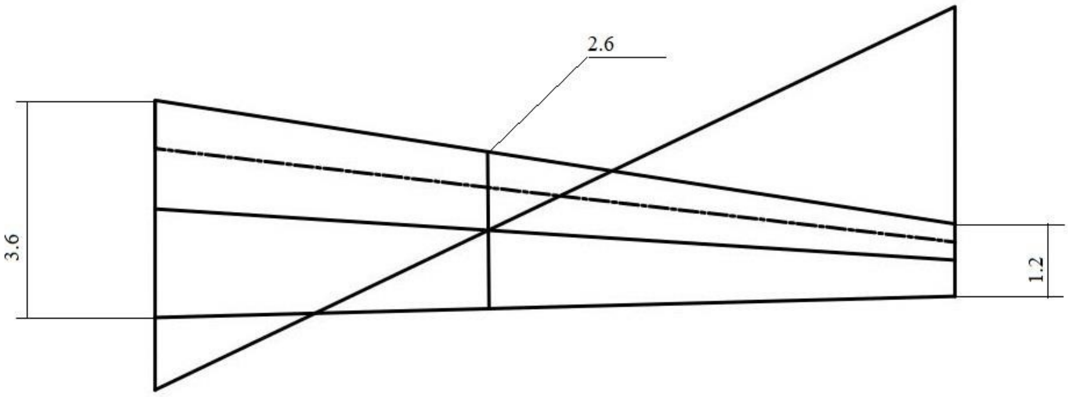


Fig. 2.1 - Geometrical method of determination of mean aerodynamic chord

To choose the force scheme of the wing it is necessary to determine the type of its internal design. The box-spar type with three spars was chosen to meet the requirements of strength and at the same time to make the structure comparatively light.

Wing’s geometry estimation, it is necessary to determine and calculate the main parameters of control surfaces.

Ailerons geometrical parameters are determined in the next order:

Ailerons span:

$$I_{ail}=0,4\cdot\frac{I_w}{2}$$

$$I_{ail}=0,4\cdot\frac{27,3}{2}=5,250\ (m)$$

Aileron chord:

$$b_{ail}=0,44\cdot b_t$$

$$b_{ail}=0,44\cdot 1,2=0,528\ (m)$$

Aileron area:

$$S_{ail}=0,06\cdot\frac{S_w}{2}$$

$$S_{ail}=0,06\cdot\frac{65,46}{2}=2(m^2)$$

The calculated above values are recommended. Increasing of aileron span and chord more than these values are not convenient because with the increase of aileron span the increase of the aileron’s coefficient falls, and the high-lift devices span decreases. In the case of aileron chord, its value increase lead to the decreasing of wing box width.

Aerodynamic compensation of the aileron:

$$S_{ax.\,ail}\leq(0,25\ \dots\ 0,28)\cdot S_{ail}$$

$$S_{ail}=0,26\cdot 2=0,52\ (m^2)$$

Area of ailerons trim tab. For two-engine airplane:

$$S_{tail} = 0{,}04 \ldots 0{,}06 \cdot S_{ail}$$

$$S_{tail} = 0{,}05 \cdot 2 = 0{,}1(m^2)$$

Range of aileron deflection for upward is 25 degrees, downward is 15 degrees.

2.2.2 Fuselage layout

Generally, the fuselage layout estimation consists of main geometrical dimensions calculation and interior scheme creation.

In case of geometrical calculation, it is necessary to take into account the expected aerodynamic characteristics of designed airplane, typical resistances during normal and extreme flight conditions in accordance with estimated purpose. Airplane's fuselage geometry should allow to avoid high values of parasitic, skin friction and wave drags, withstand the aerodynamic loads and have as greater as possible safety factor value. To decrease form and wave drug and to provide necessary strength characteristics avoiding the stress concentrators in fuselage cross-section the round shape was chosen.

Another part of fuselage calculation as interior scheme creation is based on the required capacity of designed aircraft. Besides that, the requirements of ergonomics and sanitary standards must be considered for passenger aircrafts.

The next steps are necessary to calculate the main geometrical characteristics of the fuselage and consequently to obtain its outline.

Nose part length is:

$$I_{nfp} = 2 \cdot D_f$$

$$I_{nfp} = 2 \cdot 2{,}9 = 5{,}8\ (m)$$

Fuselage length is:

$$I_f = \lambda_f \cdot D_f$$

where: λ_f – fuselage fineness ratio.

$$I_f = 8 \cdot 2{,}9 = 23{,}2\ (m)$$

Fuselage nose part of fineness ratio is:

$$\lambda_{fnp} = \frac{I_{fnp}}{D_f}$$

$$\lambda_{fnp} = \frac{5{,}8}{2{,}9} = 2$$

Length of the fuselage rear part is:

$$I_{frp} = \lambda_{frp} \cdot D_f$$

where: λ_{frp} – fuselage fineness ratio.

$$I_{frp} = 2{,}4 \cdot 2{,}9 = 6{,}96\ (m)$$

Cabin height is:

$$H_{cab} = 1{,}48 + 0{,}17 B_{cab}$$

where B_{cab} – width of the cabin.

$$H_{cab} = 1{,}48 + 0{,}17 \cdot 2{,}560 = 1{,}9152\ (m)$$

For economic class passenger cabin the location of seats in the one row (2+2) determine the next parameter:

$$B_{cab} = n_{2chblock} \cdot b_{2chblock} + b_{aisle} + 2\delta$$

where $n_{3chblock}$ – width of 2 chairs;

$b_{3chblock}$ – number of 2 chair block;

b_{aisle} – width of aisle.

$$B_{cab} = 2 \cdot 1000 + 500 + 2 \cdot 30 = 2{,}560\ (m)$$

The length of passenger cabin is:

$$L_{cab}=L_1+(n_{raws}-1)\cdot L_{seatpitch}+L_2$$

where L_1 – distance between the wall and the back of first seat

n_{rows} – number of rows;

$L_{seat\ pitch}$ – seat pitch;

L_1 – distance between the back of last seat and the wall.

$$L_{cab}=1200+(13-1)\cdot 750+300=1{,}5\ (m)$$

2.2.3 Luggage compartment

Cargo compartment volume is:

$$V_{cargo}=\nu\cdot n_{pass}$$

where ν – relative mass of baggage

n_{pass} – number of passengers.

$$V_{cargo}=0{,}23\cdot 52=11{,}96\ (m^3)$$

Luggage compartment design is similar to the prototype.

2.2.4 Galleys and buffets

Volume of buffets (galleys) is:

$$V_{galley}=(0{,}1\ldots0{,}12)\cdot n_{pass}$$

where ν – volume of buffets

$$V_{galley}=0{,}1\cdot 52=5{,}2\ (m^3)$$

Area of buffets (galleys) is:

$$S_{galley}=\frac{V_{galley}}{H_{cab}}$$

$$S_{galley}=\frac{5{,}2}{1{,}9152}=2{,}715\ (m^2)$$

Number of meals per passenger breakfast, lunch and dinner – 0, 7 kg, tea and water – 0, 4 kg.Buffet design similar to prototype.

2.2.5 Layout and calculation of basic parameters of tail unit

The chosen tail unit scheme is conventional. This choice is based on all three prototypes empennage schemes.

To estimate the general tail unit outlines it is necessary to calculate the geometrical dimensions of vertical and horizontal stabilizers and dimensions of control surfaces. In general, tail unit must to meet the requirements of aircraft stability and controllability.

Area of vertical tail unit is:

$$S_{VTU}=\frac{I_{wx}S_w}{L_{VTU}}\cdot A_{VTU}$$

where L_{VTU} – length of vertical tail unit.

$$S_{VTU}=\frac{27{,}3\cdot 65{,}46}{5{,}205}\cdot 0{,}0402=13{,}793\ (m^2)$$

Area o horizontal tail unit is:

$$S_{HTU}=\frac{b_{MAC}\cdot S_w}{L_{HTU}}\cdot A_{HTU}$$

where L_{HTU} – length of horizontal tail unit.

$$S_{HTU}=\frac{2{,}6\cdot 65{,}46}{9{,}996}\cdot 1{,}067=18{,}175\ (m^2)$$

Determination of the elevator area and direction:

Altitude elevator area is:

$$S_{el}=0,2765\cdot S_{HTU}$$

where k_{el} – relative elevator area coefficient.

$$S_{el}=0,2765\cdot 18,175=4,662\ (m^2)$$

Rudder area is:

$$S_{rud}= 0,2337\cdot S_{VTU}$$

where k_r – relative rudder area coefficient.

$$S_{rud}=0,2337\cdot 13,793=3,223\ (m^2)$$

Choose the area of aerodynamic balance:

$0,3\leq M\leq 0,6$

$S_{eb} = (0,22...0,25)\ S_{el}$

$S_{rb} = (0,2..0,22)\ S_{rod}$

Elevator balance area is:

$$S_{eb}=0,22\cdot S_{el}$$

where k_{eb} – relative elevator balance area coefficient.

$$S_{eb}=0,22\cdot 4,662=1,026\ (m^2)$$

Rudder balance area is:

$$S_{rb}=0,2\cdot S_{rud}$$

where k_{rb} – relative rudder balance area coefficient.

$$S_{rb}=0,2\cdot 3,223=0,6446\ (m^2)$$

The area of altitude elevator trim tab is:

$$S_{te}=0{,}08\cdot S_{el}$$

where k_{te} – relative elevator trim tab area coefficient.

$$S_{te}=0{,}08\cdot 4{,}662=0{,}37296\ (m^2)$$

Area of rudder trim tab is:

$$S_{tr}=0{,}06\cdot S_{rud}$$

where S_{tr} – relative trim tab area coefficient.

$$S_{tr}=0{,}06\cdot 3{,}223=0{,}19338\ (m^2)$$

Root chord of horizontal stabilizer is:

$$b_{OHTU}=\frac{2S_{HTU}\cdot\eta_{HTU}}{(1+\eta_{HTU})\cdot I_{HTU}}$$

where η_{HTU} – horizontal tail unit taper ratio
l_{HTU} – horizontal tail unit span.

$$b_{OHTU}=\frac{2\cdot 18{,}175\cdot 2{,}2}{(1+2{,}2)\cdot 9{,}996}=2{,}5\ (m)$$

Tip chord of horizontal stabilizer is:

$$b_{OHTU}=\frac{b_{OHTU}}{\eta_{HTU}}$$

$$b_{OHTU}=\frac{2,5}{2,2}=1,14\ (m)$$

Root chord of vertical stabilizer is:

$$b_{OVTU}=\frac{2S_{VTU}\cdot\eta_{VTU}}{(1+\eta_{VTU})\cdot l_{VTU}}$$

where η_{VTU} – vertical tail unit taper ratio;

l_{VTU} – vertical tail unit span.

$$b_{OVTU}=\frac{2\cdot 13,793\cdot 2,786}{(1+2,786)\cdot 5,205}=3,9\ (m)$$

Tip chord of vertical stabilizer is:

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

$$b_{OVTU}=\frac{3,9}{2,786}=1,4$$

2.2.6 Landing gear design

To estimate the landing gear outline in this project it is necessary to calculate the location of every strut in relatively to each other, to determine the loads on landing gear system, and its location considering centre of gravity of an airplane.

In this layout, the principal scheme of landing gear is fully based on the prototype data.

As in the case with the tail unit it is necessary to provide the aircraft with the stable and controllable base during operation on the ground including landing and take-off.

Main wheel axes offset is:

$$e=0,2673\cdot b_{MAC}$$

where k_e – coefficient of axes offset;

b_{MAC} – mean aerodynamic chord.

$$e=0,3\cdot 2,6=0,78\ (m)$$

Landing gear wheel base is:

$$B=k_b\cdot L_f$$

where k_b – wheel base calculation coefficient.

$$B=0,3836\cdot 23,2=8,9\ (m)$$

That means that the nose strut holds 5...11% of airplane weight.

Front wheel axial offset is:

$$d_{ng}=B-e$$

$$d_{nd}=10,5-0,78=9,72$$

Wheel track is:

$$T=k_T\cdot B$$

where k_b – wheel track calculation coefficient.

$$T=0,8315\cdot 8,9=7,4\ (m)$$

Nose wheel load is:

$$P_{NLG}=\frac{9{,}81\cdot e\cdot k_g\cdot m_0}{B\cdot z}$$

where k_g – dynamics coefficient;

z – number of wheels.

$$P_{NLG}=\frac{9{,}81\cdot 0{,}78\cdot 1{,}75\cdot 2080)}{8{,}9\cdot 2}=13263{,}12\ (N)$$

Main wheel load is equal:

$$P_{MLG}=\frac{9{,}81\cdot (B-e)\cdot m_0}{B\cdot n\cdot z}$$

where n – number of main landing gear struts.

$$P_{MLG}=\frac{9{,}81\cdot (8{,}9-0{,}78)\cdot 20800}{8{,}9\cdot 2\cdot 4}=23611{,}3\ (N)$$

2.2.7 Choice and description of power plant

In accordance with the performance of aerodynamic calculations for the design of the aircraft, the required maximum thrust at take-off mode is 165. The PW127 is a free turbine propulsion engine consisting of turbomachine and reduction gearbox modules connected by a drive shaft and integrated strucural intake case.

Turbomachine's a three concentric shaft design incorporating two centrifugal compressors each driven separately by single-stage turbines, and a two-stage power turbine.

The reduction gearbox features a twin layshaft design with antifriction bearings and an offset propeller shaft. The combustion system is comprised of an annular reverse flow combustor, 14 piloted air blast fuel nozzles, and 2 ignitors.

Table 2.2 - Examples of application PW 127

Engine Model	Overall Length (mm)	Overall Width (mm)	Dry Spec. Weight (kg)	Maximum Take-off Power – 5 min.		Normal Take-off Power – 5 min.		Maximum Continuous Power	
				Shaft Power (kW)	Maximum Air Temp for Rated Power (°C)	Shaft Power (kW)	Maximum Air Temp for Rated Power (°C)	Shaft Power (kW)	Maximum Air Temp for Rated Power (°C)
PW127	2130	679	480.8	2051	32	1846	32	1864	41

2.3. Aircraft center of gravity calculation

2.3.1 Trim sheet of equipped wing

The distance from the main aerodynamic chord to the centre of gravity of the airplane is called the centering. During the changing of the aircraft loading variants or because of the changing of weight during flight the position of aircraft cenre of is changing. The moving of the cargo inside the aircraft leads to changing of centre of mass position too.

The centering is important aircraft characteristic as it affects on the balancing, stability and controllability of the aircraft. That’s why it is necessary to keep it inside strict limits.

To calculate the centering, it is necessary to determine the mass of main structural units and devices.

The list of the units masses for the aircraft given in the table 2.3. The mass of aircraft is 20800 kg.

The longitudinal static stability of the aircraft is determined by the location of its centre of mass relatively to the focuses.

The closer the centre of mass is to the nose part of the aircraft, the more longitudinally stability the aircraft have.

Coordinates of the center of gravity for the equipped wing are:

$$X_w' = \frac{\Sigma m_i' X_i}{\Sigma m_i'}$$

Table 2.3 - The closer the centre of mass is to the nose part of the aircraft, the more longitudinally stability the aircraft have.

Name	Mass		Center of gravity coordinates	Moment (kgm)
	Units	total (kg)		
Wing (structure)	0,16	3328	1,17	3893,76
Fuel system, 40%	0,0038	79,04	1,17	92,48
Control system, 30%	0,0034	69,89	1,56	109,02
Electrical equip. 30%	0,009	187,2	0,26	48,67
Anti-icing system 70%	0,0178	371,28	0,26	96,53
Hydraulic system, 70%	0,0189	393,12	1,56	613,27
Power plant	0,1204	2504,74	1,2	3005,68
Equipped wing without landing gear and fuel	0,334	6933,26	1,13	7859,42
Nose landing gear	0,016	333,98	-5,73	-1913,69
Main landing gear	0,032	667,96	1,3	868,34
Fuel	0,134	2784,70	1,09	3040,89
Equipped wing with landing gear and fuel	0,515	10700	0,92	9836,66

2.3.2 Trim sheet of equipped fuselage

The list of the unit for the aircraft is given in table 2.4.

The center gravity coordinates of the equipped fuselage are:

$$X_f' = \frac{\Sigma m_i' X_i}{\Sigma m_i'}$$

The list of mass items for center of gravity variations calculation given in Table 2.5 and center of gravity calculation options given in table 2.6 completes on the base of both previous tables.

The mean aerodynamic chord center of gravity is:

$$X_{MAC}=\frac{m_f \cdot x_f+m_w \cdot x_w-m_0 \cdot c_n}{m_0-m_0}$$

where m_0 – aircraft takeoff mass, kg

m_f – mass of equipped fuselage, kg

m_w – mass of equipped wing, kg

Table 2.4 - Trim sheet of equipped fuselage masses

Objects	Units	Total (kg)	Coordinates of center of gravity, (m)	Momentum (kgm)
Fuselage	0,1135	2361,84	11,6	27397,34
Horizontal stabilizer	0,0156	325,94	20	6518,72
Vertical stabilizer	0,0155	323,02	18,2	5879,03
Radiolocation equipment	0,0046	95,68	11	1052,48
Dashboard with equipment	0,008	166,4	2,2	366,08
Aeronavigation equipment	0,0069	143,52	3,5	365
Radio equipment	0,0034	70,72	3,5	502,32
Lavatory	0,0009	113,68	13,4	247,52
Galley	0,0054	113,68	12,8	1523,36
Baggage equipment	0,0009	20,11	5,1	1455,15
Control system	0,0078	163,07	9,8	102,54
Electrical system 70%	0,021	436,8	12,8	1598,10
Hydraulic system 30%	0,0081	168,48	10,1	5591,04
Anti-ice system 30%	0,0076	159,12	9	1701,65
Onboard equipment	0,008	166,4	3,5	1432,08
Passengers seats	0,0146	240	9	582,4
Emergency equipment	0,0048	100,64	5,1	2160
Cockpit seats	0,0009	20	2,5	513,26
Attendant seat	0,0002	8	12,9	51
Non-typical equipment	0,0024	49,92	0	51,6
Equipped fuselage without	0,2508	5247,02	11,2	58776,29
Passengers	0,1730	3600	8,7	31320
Passenger baggage	0,0230	480	5,1	2448
Cargo	0,0260	542	5,1	2764,2
Crew	0,0067	140	2,5	350
Flight attendant	0,0024	50	12,9	645
Equipped fuselage with commercial load	0,4846	10100	9,59	96948,49

After the calculationg of the centre of gravity for the all masses in the wing and all masses in the fuselage we could come the the next step – attachment of a wing with fuselage. After the X_{MAC} determination we could come the the centre of gravity range for equipped aircraft.

Table 2.5 - Calculation of center of gravity positioning variants

Name	Mass, kg	Coordinates	Moment
Object	m_i	m	kgm
Equipped wing without fuel	6933,264	10,119	70161,53
Nose landing gear (retracted)	333,978	8,9	1087,423
Main landing gear (retracted)	667,9	10,604	7082,727
Fuel	2784	10,409	28981,36
Equipped fuselage	5247,026	11,202	58776,3
Passengers	3600	8,7	31320
Baggage of passengers	480	5,1	2448
Cargo	542	5,1	2764,2
Crew	140	2,5	350
Attendants	65	12,9	838,5
Nose landing gear (extended)	333,978	2,256	753,445
Main landing gear (extended)	667,9	10,604	7082,727

Table 2.6 - Aircraft center of gravity position range

Variants of the loading	Mass, kg	Momentum of the mass, кg·m	Center of mass, m	Centering
Take-off mass (nose landing gear extended)	20800	203648,545	9,811	25,50%
Take-off mass (nose landing gear retracted)	20800	203314,567	9,795	25,00%
Landing variant (main landing gear extended)	17258	167170,876	9,686	21,64%
Transportation variant (without payload)	16236,17	167782,367	10,333	18,87%
Parking variant (without fuel and payload)	15182,17	137107,983	10,401	15,35%

The most forward and the most aft centre positions are 15,35% and 25,5% from leading edge of mean aerodynamic chord.

Conclusion to the part

In this part the preliminary design of short range passenger aircraft was performed. All initial data were taken on the base of statistic data of prototypes. The main geometrical paramenters and design dicisions were conducted in this part. The centre of gravity range for the equipped aircraft was calculated to provide longitudinal trim of the aircraft in cruise flight. The preliminary design of the aircraft gives possibility to make drawings – general view and aircraft layout.

The center of gravity calculations of the aircraft was performed. The most forward center of gravity position of designing aircraft is 15,35% from the leading edge of mean aerodynamic chord. The most aft center of gravity position of equipped aircraft is 25,5% from the leading edge of mean aerodynamic chord.

The engine PW-127J that meets all requirements in efficiency for designed aircraft was chosen.

PART 3. CONCEPTUAL DESIGN OF THE PAASENGER SEAT WITH SHOCK ABSORBER

Flying in an airplane for an ordinary passenger is not very familiar both psychologically and physiologically. One of the main tasks of the designer is to a living environment on board a passenger aircraft that's as near as possible to the normal "earthly", "residence" consolation conditions in terms of climate and noise level, in terms of the common aesthetic impression of the interior of the passenger cabin (cabin) of the aircraft and service in flight, for the convenience of accommodating passengers.

Nearly 95-96 percent of the time on board the aircraft, the passenger spends being in the seat, therefore the passenger seat is the most necessary equipment of the aircraft cabin , and the passenger's assessment depends on how comfortable it is and how other elements of equipment are arranged around it. That’s provide comfort and service in flight. Flights condition, the choice of an aircraft of a certain airline and, as a result, its profit. In the practice of air transportation, various classes of cabins are used, differing in the level of service and accommodation of passengers in flight, there is a wide range of passenger seats that ensure a comfortable stay of a passenger in flight and safety in an emergency. The seats are planned considering the anthropological information of an individual, they're made of high-strength materials that meet fire safety requirements, and with a low wt (for a 3-seater obstruct of chairs – 22-25 kg, for a 2-seater block – 14-17 kg) they have high strength characteristics, which allows, thanks to the equipping of the seat with seat belts, to ensure the survival of the passenger during an emergency landing with an estimated overload of up to sixteen. Thus, the seat is not only a portion of the passenger onboard equipment, but also an element of the rescue system. The seats that allow the minimum requirements for consolation are equipped with a tillable backrest that can be fixed in any position for the convenience of passengers, reclining seats and armrests to an upright position for simple passage of passengers and cleaning the cabin during aircraft maintenance at airports. In the design of the seats, there are rubbish bins (ashtrays), life jackets in covers, on the back of the seat there is an individual for the following row passenger.

Front seats are introduced on guide rails recessed into the floor, which permits you to alter the distance between them straight ("seat pitch") and rework the traveler compartment as per the lodge class. Seats for higher class lodges, for instance, business class (VIP-cabin - very important person), give conditions to both unwinding, including rest, and for effective work in flight, and have an expanded width of cushions and armrests, just as enormous (up to 65 °) points of backrest redirection, outfitted with a retractable footstool, furnished with a front table mounted on the armrest, a button for calling an airline steward (airline steward), individual lighting, a fan, a square of connectors for interfacing sound transmission earphones and gadgets radiotelephone correspondence. Seats of the team individuals from traveler airplane are likewise ordinarily alluded to as traveler on-board gear. For guarantee an agreeable place of the pilot comparative with the control switches, instruments and cockpit coating, the pilot's seats are flexible in the even and vertical ways, just as the backrest point. Some of the time the aide rails of the pilots' seats approve them to be dislodged back and sideways for simplicity of section and exit, just as for moving toward remote instrument boards and their control handles.

Onboard passenger’s equipment includes facilities and equipment for in-flight entertainment (for example, video broadcasting), wardrobes and luggage racks, kitchens and cupboards, toilets.

Normally, the dimensions of this equipment, the dimensions of the seats, the step size of the seats, the number and width of aisles between the rows of seats significantly affect the fuselage layout and dimensions.

Increasing the level of comfort on board increases aircraft weight and operating costs. Notwithstanding, an increase in the level of comfort on long-haul wide-body aircraft (where there are 8-10 seats in a row with 2-3 central aisles between them) increases the inflow of passengers on highly comfortable aircraft and the income of the airlines operating them, which should inevitably lead to an increase in the level of comfort on light aircraft. short airlines.

For increasing of economic efficiency of passenger aircraft is also possible due to their use for solving other special transport problems.

A series of air crashes that have occurred in recent years forces us to pay special attention to ensuring the safety of passengers when aircraft hit the ground. In various case of disasters shows that in some of them, a certain proportion of passengers could be saved if the protection against shock loads were more perfect. In a number of cases, the destruction of the seats was directly related to the injuries and death of passengers.

Aircraft impacts on the ground during an accident are characterized by the emergence of forces of a high slew rate, a large magnitude and a short duration of action. There is documentary evidence of the survival of people after exposure to accidental shock loads, the magnitude of which was much higher than the loads obtained in experiments with human participation (the range of shock loads carried by a person is four to ten times higher than the loads recorded experimentally).

In the event of an emergency landing of the aircraft, the impact energy is transmitted in the direction of the cabin floor - the seat, and there is an interaction between the passenger and the harness. If there is enough free space in front of the chair, the head with the body and limbs of the passenger, fastened to the chair with a lap belt, take an almost horizontal position after the impact. Approximately to this moment, the tension force of the belt that surrounds the person and is fixed on the chair with its ends reaches its maximum value. (As shown by our calculations, the force acting on the chair can be approximately twice the force obtained by multiplying a person's mass by acceleration.) This increase in the load on the chair is associated with the appearance of large forces in the moving parts of the body (arms, legs, trunk with the head) in the process of translational and rotational movements of these parts and a more complex law of braking of moving parts of the body than the floor of the passenger compartment. Practice shows that if the seat remains in its place and does not collapse, then survival is possible and has repeatedly taken place in plane crashes with the values of inertial forces significantly exceeding those indicated in § 25.561 FAR-25 (1993). This is confirmed by the experimental data accumulated over the past two decades. The trajectory of the passenger's torso and its subsequent folding at the moment of the aircraft hitting the ground in the presence of only a lap belt are such that a collision with obstacles in front is almost inevitable. Therefore, even minor shock loads (eg to the head) can lead to fatal injuries. Thus, a significant increase in the protection of passengers from shock loads can be achieved by providing the passenger with additional shoulder harnesses. At present, as you know, except for the crew members, no one on board the aircraft has such belts. Since the shoulder harness belts are retracted into the back of the seat at shoulder level (or slightly higher), the increased height of the point of application of the resultant force applied to the seat will inevitably require an increase in the strength of the seat structure compared to a conventional passenger seat (equipped with only a lap belt). Note also that the installation of seats against the flight in the presence of head restraints will contribute to a significant increase in the limit of human tolerance to shock loads (this is due to the distribution of the acting forces over a larger area) than in the case of using seat belts. On the basis of the above, the following priority task can be formulated: it is required to consider, in a stricter formulation than has been done so far, the problem of loading the chair by inertial forces from a person who is fastened to the chair with belts. Take into account the flexibility of the shoulder attachment due to the bending of the back of the chair and the deformation of the belts. Having a solution to this problem, we can further pose the problem of creating energy-absorbing chairs with plastically deformable legs and using new materials. This is already a complex task of rational design, requiring CB aero to solve a different model. A high degree of detailing of the mathematical model approximating a real structure is allowed by the finite element method, which is widely used in calculations for static strength, but the mechanical transfer of the developed methods and programs to the field of dynamic calculations is actually impossible due to an extremely sharp increase in the required expenditures of computer time and computer memory. After the emergence of supercomputers, the definitions of a fundamental nature have decreased, but issues related to the cost of such calculations (especially parametric ones) force us to continue looking for ways to reduce the dimension of the problem. One of the ways to effectively simplify the mathematical model is the so-called discrete-element approach: the structure is represented by a relatively small set of concentrated masses (rigid bodies) connected by linear and nonlinear springs that simulate the stiffness and strength characteristics of macro parts of the structure. The parameters of such macronutrients should be determined either by special experiments or using detailed finite element analysis. The machine time required for detailed modeling can vary from several tens of minutes for the simplest hybrid models to 100 or more hours for large models. Attempts to simulate the dynamics of the human body are associated, on the one hand, with the advent of modern computers, and on the other hand, with increased safety requirements for vehicles. For example, computer programs have been created abroad and are used quite intensively, which simulate the human body with varying degrees of detail. The simplest of them are limited only by taking into account the general features of the mechanical system, which is the human body. In particular, in the design of US helicopters for vertical impact on the ground, a mathematical model is used that includes four masses and four springs. This takes into account the movement relative to each other of the rollers, the upper and lower parts of the torso and the seat of the chair. There are data on more complex models of the human body based on the nonlinear finite element approach, but we do not have data on either calculation algorithms or programs. In this work, an original model of the human body is proposed, which is a system of five rigid bodies (links) connected by hinges. Each link has a given size, mass, center of mass position and moment of inertia. When calculating the dynamic response of a seat with a person to an overload set on the floor of the aircraft cabin, the following parameters of a person's body weighing 90 kg are used.

According to the requirements set out in Chapter 25.562 of the Aviation Regulations, each typical design of a seat must successfully pass dynamic tests or be evaluated by means of a computational analysis based on dynamic tests of a similar type of seat in accordance with each of emergency landing conditions.

The dynamic analysis equation is:

$$[M]\{\ddot{u}\}=\{f\},$$

where $[M]$ – the mass matrix;

$\{\ddot{u}\}$ – vector of applied forces;

$\{f\}$ – vector of accelerations

Refer to Fig. 3.1, carried out by the Serov Engineering Scientific Center, the loads on the attachment points (see Fig. 3.3) of seats to the rails were obtained in the pulse duration range of 0-160 ms (the interval of the shock pulse change, see Figure 3.3) at a maximum overload of 16g. Further, in the Ansys WB 13.0 environment, computer modeling of the process of elastic-plastic deformation of a structure was carried out taking into account the contact interaction of mating parts (nonlinear static analysis).

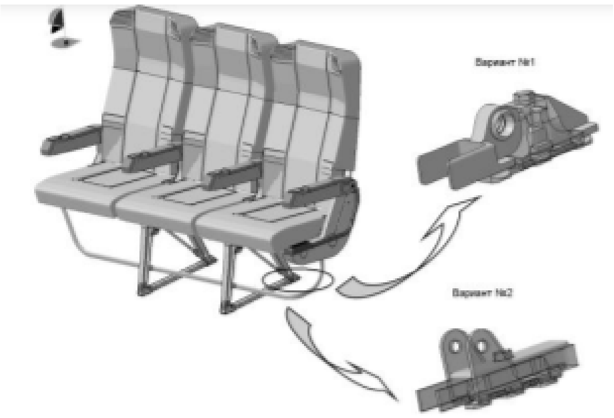


Fig. 3.1. General view of the block of seats and options for the design of the nodes of its attachment to the rails

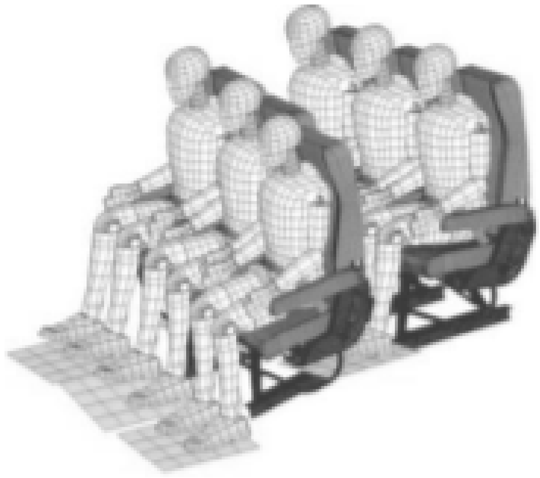


Fig. 3.2. FE model (on LS-DYNA)

Fig. 3.3. Loads on nodes

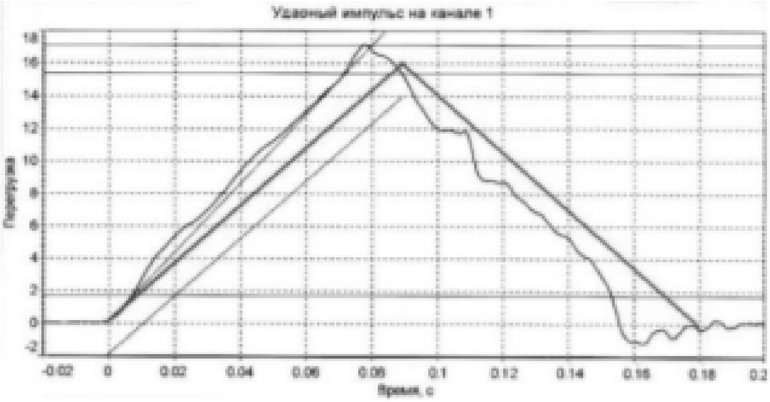


Fig. 3.4. External (shock) impulse

Initial data for analysis 1. Maximum design load acting on the rear attachment point of the chair leg to the rail P 17970 N 1831 kgf max (see Figure 3.3)

Constructive design of the nodes for fastening the rear legs of the passenger seat and solid 3D models of the nodes are shown in Figure 3.7 and 3.8

Physical and mechanical characteristics of the materials used

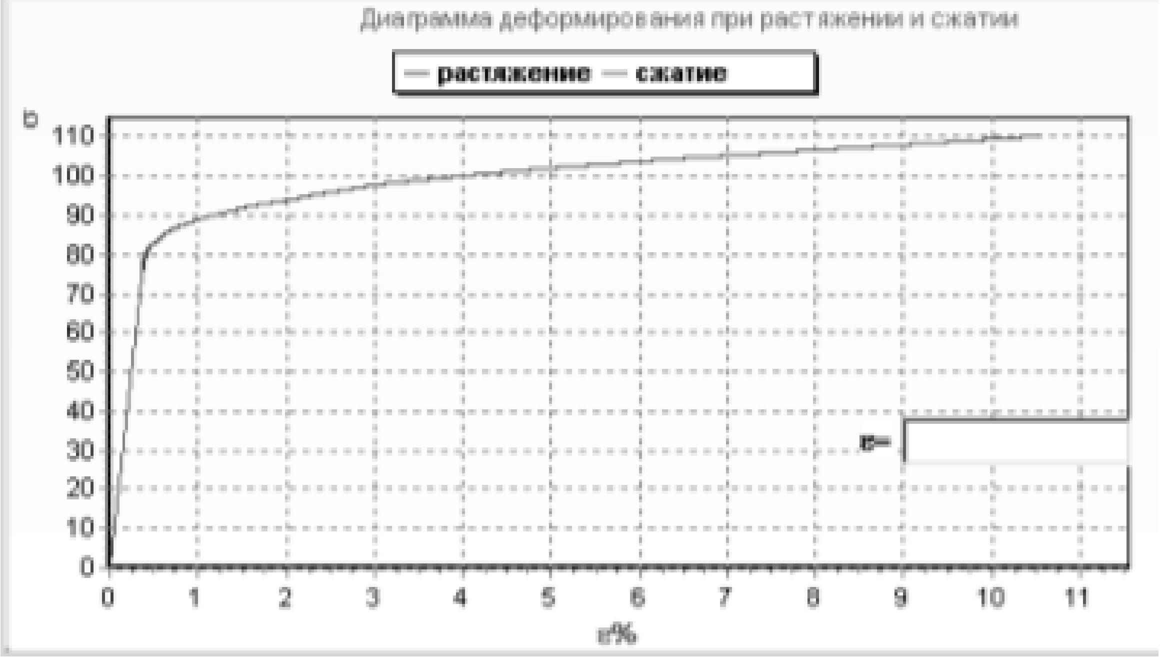


Fig.3.5. Diagram of tension 30HGSA

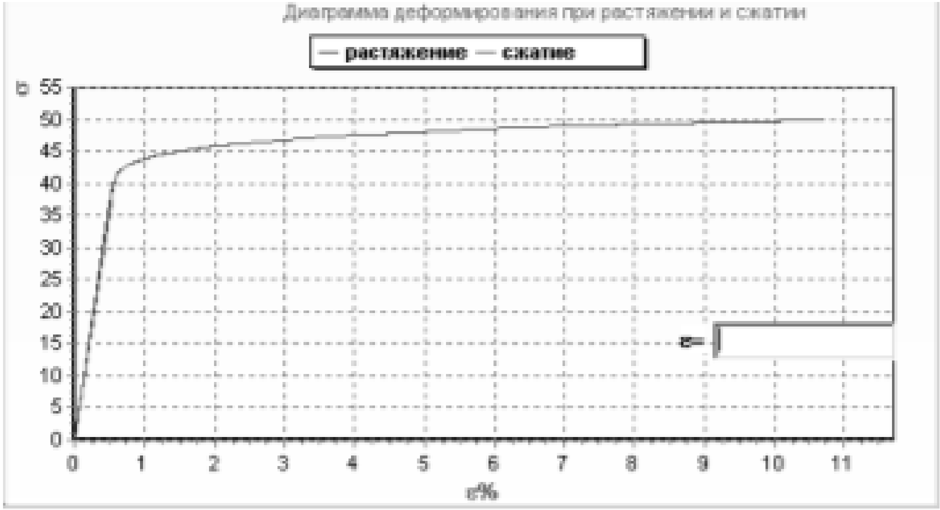


Fig. 3.6. Tension diagram V95ochT2

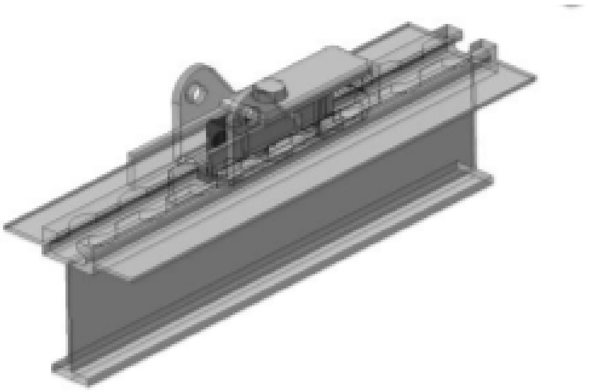


Fig. 3.7. Variant node No. 1

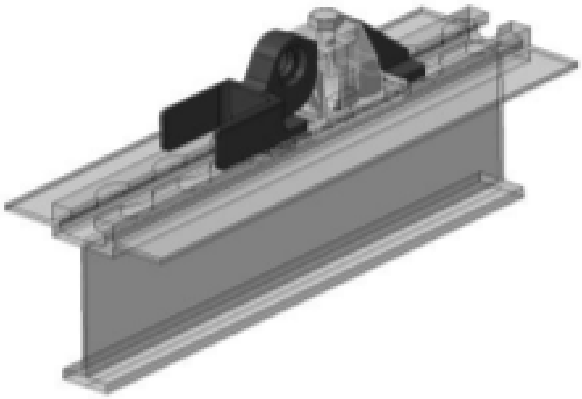


Fig. 3.8. Variant of node No. 2

Building a finite element model. Structural modeling is carried out by elements of a continuous medium such as SOLID. Dimension of the problem for node No.1: Number of nodes Node = 91444; Number of elements N_{el} = 37294. Dimension of the problem for node No.2: Number of nodes Node = 113659.

Number of elements N_{el} = 27823 In Figure 3.9 and 3.10 shows finite element models

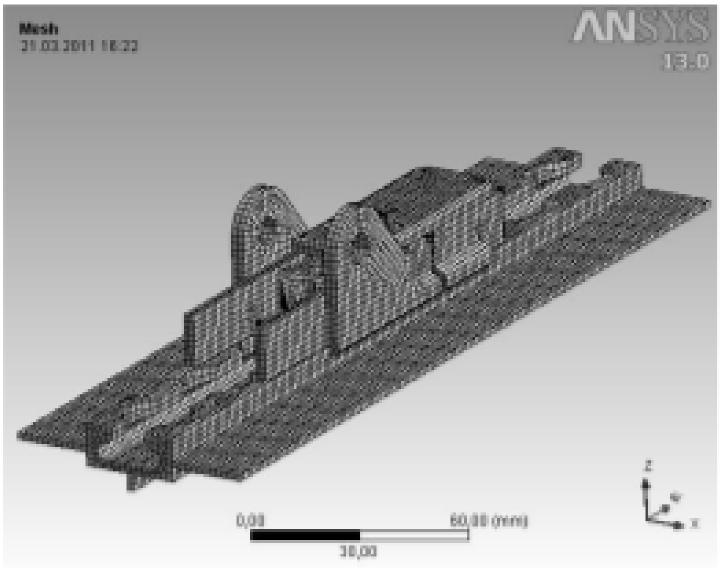


Fig. 3.9. FEM of node No. 1

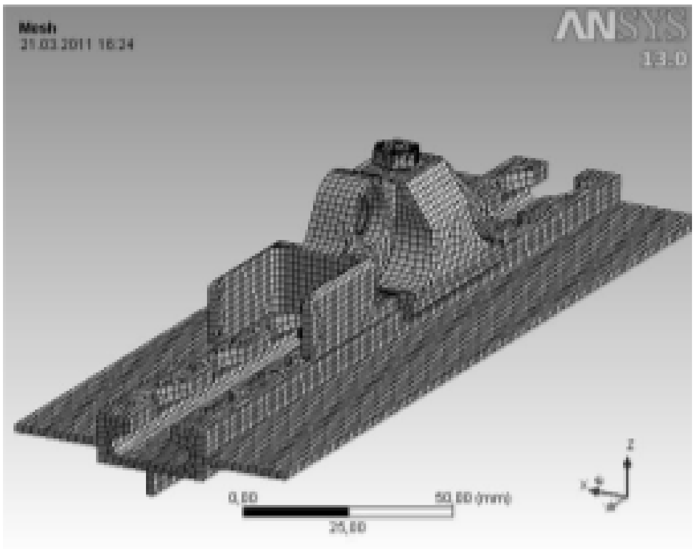


Fig. 3.10. FEM of node No. 2

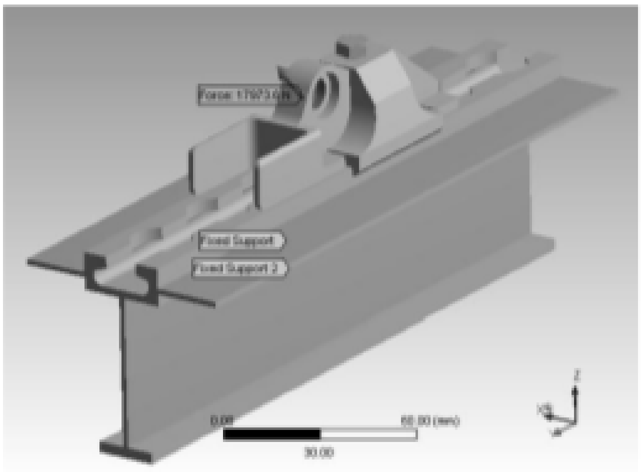


Fig. 3.11. Design scheme

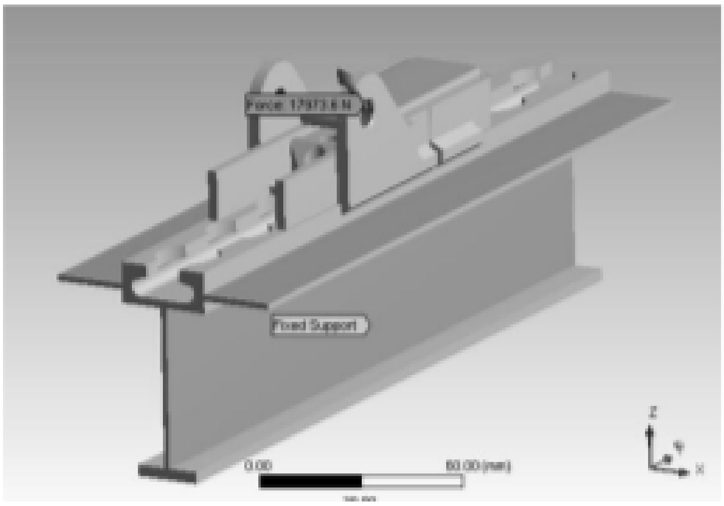


Fig. 3.12. Calculation scheme

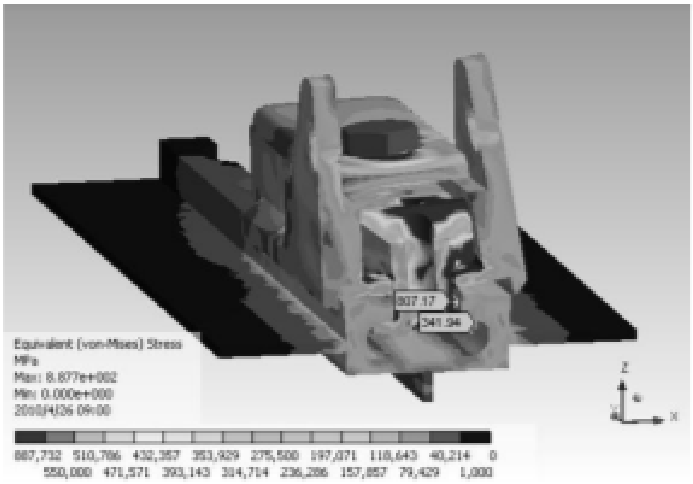


Fig. 3.13. Equivalent stresses in the details of unit No. 1

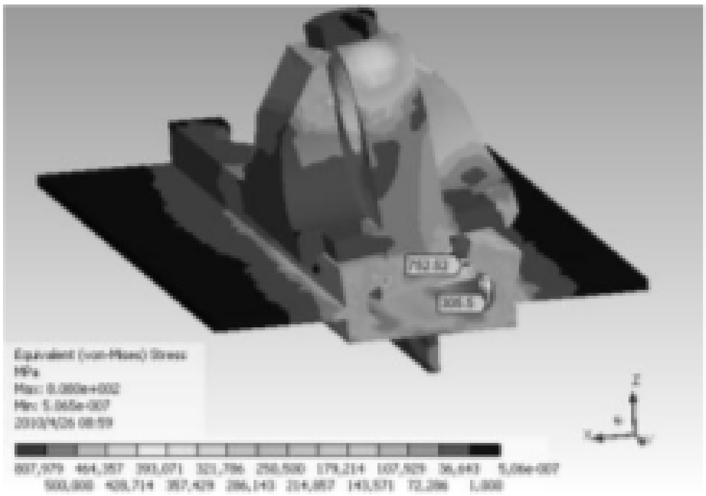


Fig. 3.14. Equivalent stresses in the details of unit No. 2

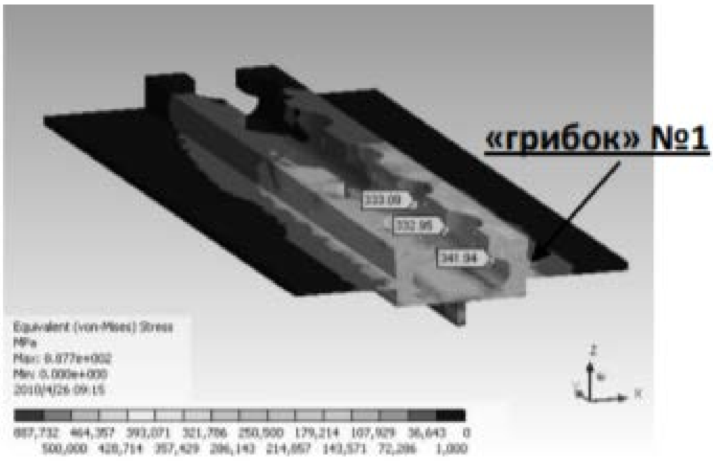


Fig. 3.15. Equivalent stresses in the rail (node No. 1)

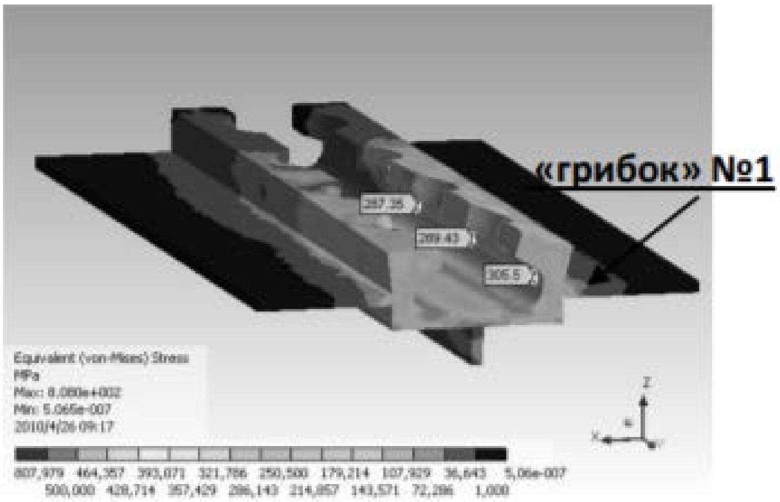


Fig. 3.16. Equivalent stresses in the rail (node No. 2)

The calculation of the loading of the attachment point for the rear leg of the passenger seat has been performed. With an equivalent load, the nature of the deformation of the rail and the attachment points of the rear leg of the chair is practically the same for two variants (see Figure 3.13 and 3.16). The stresses in the rail flanges along the first "fungi" at the points of contact with part No. 2, in version No. 1, are more than 11% higher than in the part in version No. 2 (see Figure 3.13, 3.14). The presence of relief holes d = 6.2 mm in part No. 2 creates a stress concentration in the "fungi" (see Figure 3.15, 3.16) exceeding the stress level in a similar part No. 2 by 6%. Based on the results of the calculation, it can be concluded that the variants of the structural design of the attachment points for the passenger seat blocks considered in the report provide static and dynamic strength under conditions of an emergency landing of the aircraft, as well as the attachment of the seats to the floor in the entire range of specified overloads.

The energy-absorbing chair contains a frame, two vertical rails rigidly fixed to the backrest, two shock absorbers, two vertical struts, the lower bases of which are rigidly fixed to the platform, and a headrest. The platform, on which the vertical posts and the frame are located, is connected with the floor channels, at the ends of which hinged sliders are installed, by means of the axis, the tilt angle adjustment clamps and the tilt angle sector. The platform has a common axis of rotation with the channels. A C-shaped groove with a lock is made on the front edge of each of the vertical struts. The groove contains an I-profile with an energy absorbing element (rail), which has a number of holes for moving relative to the rack. Each of the vertical guides of the frame, on which a support made of a material with a low friction coefficient is installed to reduce the sliding friction of the frame relative to the rack, is rigidly connected to the profile and the energy-absorbing element by a shear element. The shock absorber (cutter), made in the form of a U-shaped plate, is mounted in the guide of the chair and encompasses the energy-absorbing element with its U-shape. Effect: increasing the shock-absorbing stroke of the chair when hitting the ground, reducing the weight of the chair. Under operational loads, the seat frame is kept from moving by means of shock absorbers that fix the movable part of the turntable during an emergency landing, when the vertical shock load of the helicopter exceeds the permissible load, the chair frame moves downward, acting through the turntable on the shock absorbers, which, moving apart, absorb impact energy.

The technical objective of the invention is to increase the available damping stroke of the chair when hitting the ground, reduce the weight of the chair and expand the functionality of the chair by introducing ergonomic adjustments, the possibility of using various frame options and equipping the chair with heating.

The technical result is ensured by the fact that the shock absorber (cutter), made in the form of a U-shaped plate, is directly mounted into the guide of the chair and its U-shaped shape covers the energy-absorbing plate placed in the rack, which makes it possible to increase the shock-absorbing stroke of the chair due to the absence of intermediate parts and assemblies under the seat, while reducing weight.

Adjustments for the angle of inclination of the backrest, horizontal movement, vertical, as well as the presence of height-adjustable armrests and the possibility of adjusting the position of the headrest allow the chair to be used in a wide range of anthropometric indicators.

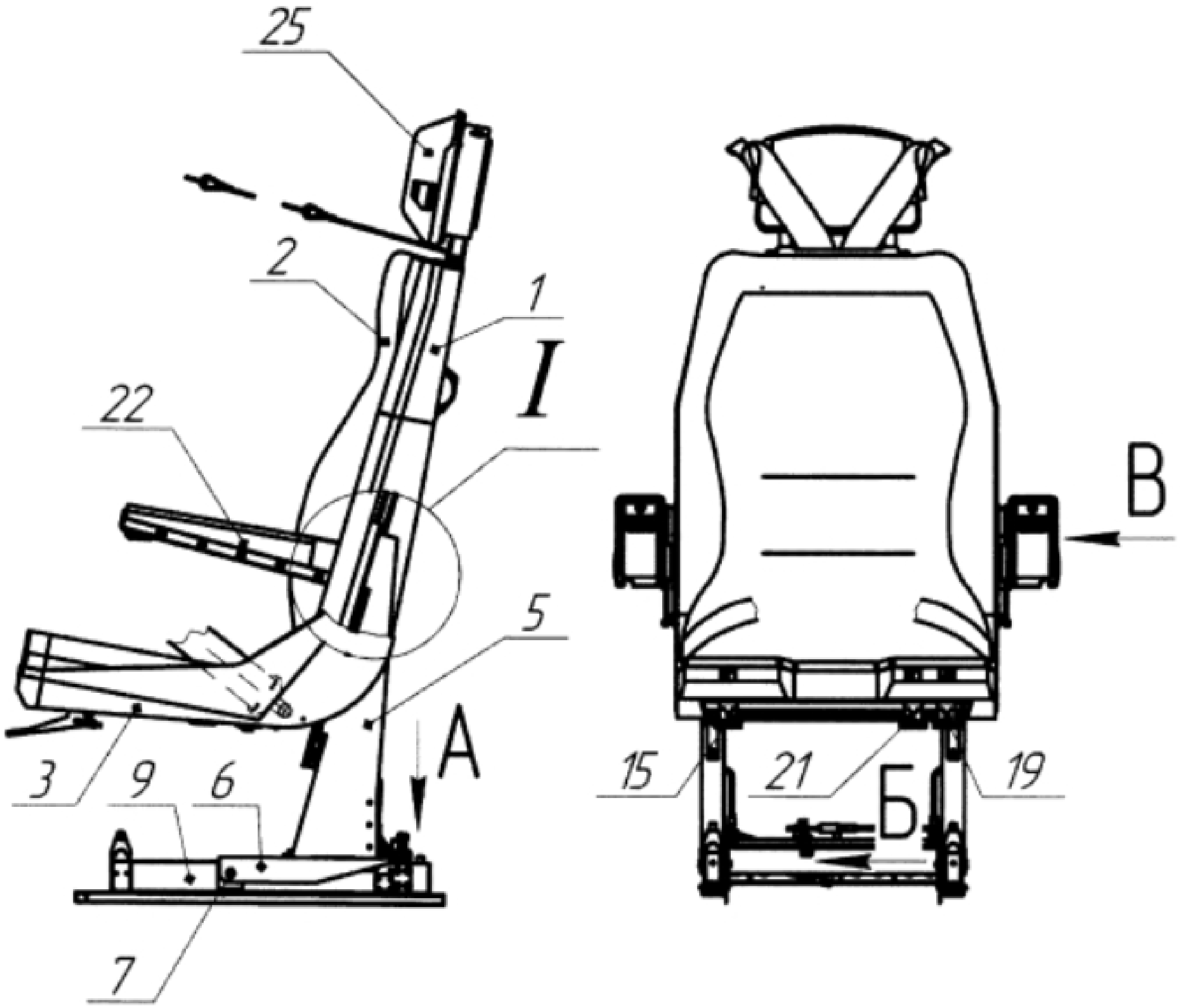


Fig. 3.17 General view of the energy-absorbing air seat

The proposed energy-absorbing seat of the aircraft consists of the frame of the seat 1, which includes the back 2 and seat 3, two vertical guides 4, rigidly fixed on the back 2, two vertical struts 5, rigidly fixed on the platform 6.

The platform 6 is connected to the floor channels 9 by means of the axis 7, the tilt adjustment locks 8 and the tilt angle sector 18. The platform 6 has a common axis of rotation with the channels 9, which allows it to change the angle of inclination.

At the ends of the channels 9 there are hinged sliders 10, which allow the chair to move in the rails 11.

The sliders 10 are locked by horizontal adjustment latches 20, which are controlled by the handle 21.

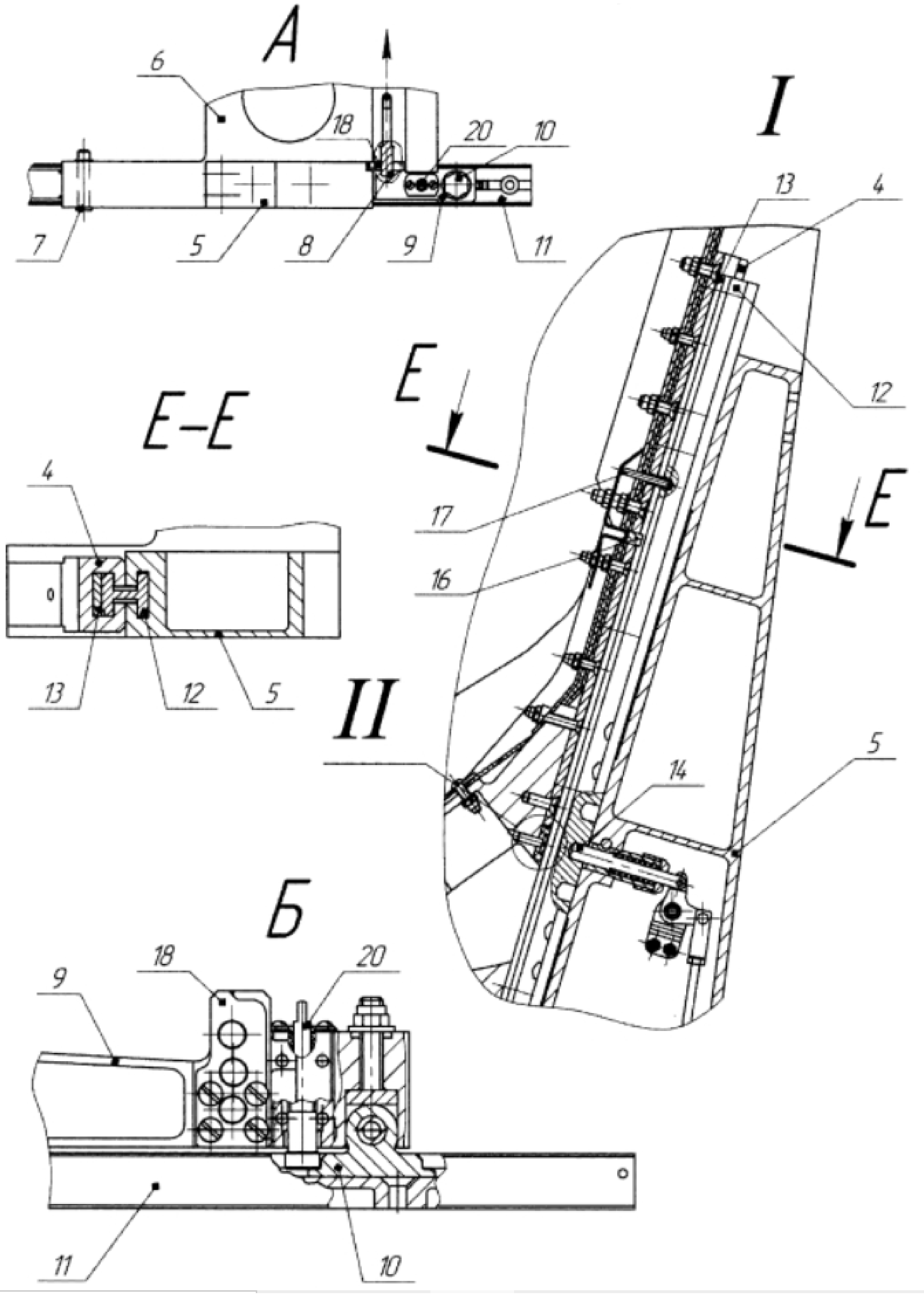


Fig. 3.18 - The difference in the direction of forces on the energy absorbing chair

On the front edges of the vertical struts 5, C-shaped grooves are made with latches for height adjustment 14. The latches 14 are controlled by the handle 15.

In the C-shaped grooves there are I-profiles 12 with energy absorbing elements (rails) 13, which have holes for moving relative to the racks 5.

Guides 4 are rigidly connected to profiles 12 and rails 13 by shear elements 17.

Shock absorbers (cutters) 16 in the form of U-shaped steel plates are mounted in the guides 4.

On the side surfaces of the backrest there is a headrest 25 and profiles 23 for moving the armrests 22 along them. The height of the armrests 22 is adjusted by moving along the profiles 23.

To reduce the sliding friction of the frame 1 relative to the struts 5, supports 24 made of a material with a low friction coefficient, such as polyamide, are installed on the vertical guides 4, which eliminates the effect of friction between parts 4 and 13 on the operation of the shock absorber.

The work of the energy-absorbing seat of the aircraft is carried out as follows.

Under operational loads, the frame of the chair 1, together with the person sitting on it, is kept from moving by means of shear elements 17.

In the event of an emergency landing of the aircraft, when the shock load acting on the person sitting in the seat exceeds the permissible limits in value, the frame of the seat 1 moves downward. In this case, the shear elements 17 are cut off and the cutters 16 begin to work, cutting off the chips on the sides of the rails 13, thereby absorbing the energy of the shock load.

Thus, the movement of the chair along the struts in the absence of structural units and parts under the seat, which allows the chair to use the maximum stroke during shock absorption, shock absorbers mounted in the rails, reducing the weight of the chair, the presence of adjustments, seat heating and the possibility of using various frame options allow expanding the functionality of the chair.

In the event of an emergency landing of the aircraft, when the shock load acting on a person sitting in the seat exceeds the permissible limits in value, the frame of the seat 1 moves downward. In this case, the shear elements 17 are cut off and the cutters 16 begin to work, cutting off the chips on the sides of the rails 13, thereby absorbing the energy of the shock load.

An energy-absorbing seat of an aircraft containing a frame that includes a seat and a backrest, two vertical rails rigidly fixed to the backrest, two shock absorbers, two vertical struts, the lower bases of which are rigidly fixed to the platform, a headrest, characterized in that the platform on which the vertical posts and frame, by means of an axis, tilt angle adjustment clamps and a tilt angle sector, is connected to floor channels, at the ends of which hinged sliders are installed, allowing the chair to move in the rails and stopping with clamps, the platform has a common axis of rotation with the channels, which allows it to change the angle of inclination, a C-shaped groove with a lock is made on the front edge of each of the vertical posts, an I-profile with an energy absorbing element is placed in the groove.

Holes for movement relative to the rack, each of the vertical guides of the frame, on which a support made of a material with a low friction coefficient is installed to reduce the sliding friction of the frame relative to the rack, is rigidly connected to the profile and the energy-absorbing element by a shear element, a shock absorber covering the energy-absorbing element is mounted in it, made in the form of a U-shaped plate, the seat is equipped with heating, profiles with armrests are installed on the side surfaces of the backrest.

Conclusion to the part

The specific design of the passenger’s seat for economy class cabin is conducted in this part of diploma work. The key idea of the seat concept is in the usage of shock absorber for the legs of a seat, supporting strut will be equipped with the actuator to reduve the vertical impact on passenger body during emergency landing. Due to shock absorbers, and also strengthening of construction the passenger seat will reduce the total load and even the HIC criteria. There was the load calculation of seat back leg in combination with the attachment to the floor. The loading framework of the seat fix movable part of turning platform at crash-landing. Due to it, have a chance to decrease the injury of passengers at crash landing.

PART 4. ENVIRONMENTAL PROTECTION

4.1. Impact of air transport on the environment

Membership in ICAO requires our country to comply with the provisions of the document "International Standards and Recommended Practices", which is an annex to the Convention on International Civil Aviation. This document presents the international standards for aircraft engine emissions and noise that have been in effect since 1993. Emissions regulations were tightened in 1996, 2004 and 2008; in particular, with respect to NO_r In 2010, at the 37th ICAO Assembly a decision was made on a new tightening. So, it was decided to stop from December 31, 2012 the production of engines that do not meet the ICAO 2008 standards and to tighten the NO_v emission standards from January 1, 2014 by another 5-15% in relation to the 2008 standards. In addition, forecast levels of emission reductions for some engines were approved relative to the 2008 standards by 45% by 2020 and by 60% by 2030. It was also decided in 2013 to develop a new standard for carbon dioxide emissions for subsonic aircraft weighing more 32.5 tons with a planned decrease of 20% by 2020 and by 50% by 2050.

The problem of the impact of $C0_2$ and NO_v on the climate may require setting a standard for emissions in the upper atmosphere. The generalized report of the International Commission "Aviation and the Global Climate of the Earth" shows that in addition to direct atmospheric pollution with carbon and nitrogen oxides ($C0_2$ and NO_v), the emission of aircraft engines in cruising flights of modern aircraft leads to the formation of condensation trails, which causes the formation of cirrus clouds and this disrupts heat transfer between the atmosphere and the earth's surface. At all stages of the airplane during the combustion of jet fuel is produced each kg 3.1 kg $C0_2$ and 1.24 kg of water. Along with $C0_2$, trails of condensation and cirrus clouds are evenly distributed in the atmosphere and contribute to the greenhouse effect.

The International Civil Aviation Organization has introduced a qualitatively new approach to the environmental performance of aircraft (AC), in which, even at the stage of formation of the concept of the aircraft being created, such characteristics should be laid down that will ensure the least negative impact on the environment, passengers and crew. The use of this approach provides for a detailed study of the options for using the created aircraft, a flight database, zones of negative influence of the aircraft near airports, as well as the impact on the climate during cruise flight modes. Later on Environment Protection Committee of the harmful effects of the ICAO Aviation decided to develop a uniform methodology for calculating the amount of emissions of $C0_2$ by types of aviation technology. The development of technologies to reduce noise and emissions is a top priority for ICAO, since the adoption in 2013 of new toughened standards for aviation ecology depends on its results.

Noise emissions from aircraft and public exposure around airports are also a major health concern and biota. The first ground noise standard for subsonic jet passenger aircraft (Appendix 16 to the Chicago Convention) was developed by ICAO in 1971, and later noise standards were adopted for other types of aircraft (propeller driven aircraft, helicopters). In 1981, ICAO expanded the scope of Appendix 16 to include requirements for harmful gas emissions. A new name for Appendix 16 has appeared - "Environmental protection". Aircraft noise standards are reflected in Annex 16, Volume 1. In 2002 and 2006. there was a tightening of acoustic requirements. More stringent restrictions on the operation of aircraft are not expected until at least 2015.

The introduction of stricter noise standards in the European Union in 2006 led to the fact that a significant part of the fleet of domestic long-haul aircraft of Russian airlines fell under the ban on flights to European airports as not meeting acoustic standards. In Russia, there was a shortage of domestic acoustically perfect aircraft, so airlines began to acquire foreign aircraft and use them for international flights.

Within the CIS, environmental requirements for both operated and newly created aircraft are regulated by the Aviation Rules AP-34 "Environmental Protection", corresponding to the recommendations of Appendix 16 to the ICAO Convention on International Civil Aviation.

In addition to environmental requirements for the emission of harmful substances and noise, the environmental policy pursued by ICAO is focused on eliminating such a harmful effect of the operation of supersonic passenger aircraft (SPS), such as sonic boom. The first resolution in this area was adopted in 1968 three months before the start of test flights of the world's first ATP, the Tu-144. In the development of ICAO's activities, an expert group was created, then transformed into a Committee on sonic boom, in order to develop proposals for the standardization of sonic booms. However, for several decades it has not been possible to formulate criteria for acceptable levels of perception of sound beats created by the SPS, although the world community recognized the significant harm from them. In the period 2002-2010.

Requirements for ships of the sea and river fleet. Passenger and cargo ships are one of the main pollutants of the aquatic environment, therefore they are subject to increased requirements for environmental friendliness of operation, set out in the "International Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978 to it", or abbreviated MARPOL 73 / 78.

The convention contains six annexes regulating the requirements for ships to prevent environmental pollution:

-Appendix I - “Regulations for the Prevention of Oil Pollution”;

-Appendix II - “Regulations for the Prevention of Pollution by Noxious Liquid Substances in Bulk”;

-Appendix III - “Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packages, Freight Containers, Removable Tanks and Road and Rail Tank Cars”;

-Appendix IV - “Regulations for the Prevention of Pollution by Sewage from Ships”;

-Appendix V - Regulations for the Prevention of Pollution by Garbage from Ships;

-Appendix VI - “Regulations for the Prevention of Air Pollution from Ships”.

The Convention obliges the ships of all signatories to prevent any violation of its requirements aimed at preventing pollution of the marine environment by dumping harmful substances or effluents from ships. To check whether the vessel has discharged hazardous substances, it can be inspected by the administrative authorities of the host country of the vessel. The countries that have signed the convention assist each other in training technical personnel, supplying equipment for receiving effluents, instruments for measuring their volumes, and promoting other measures to reduce pollution of the marine environment.

Masters of ships are obliged to immediately report all incidents resulting in the discharge of harmful substances into the sea as a result of damage to the ship itself or its equipment, as well as in order to ensure its safety or save life at sea. Messages are forwarded to the nearest coastal state with maximum urgency.

The Convention determines that ships built after its entry into force must comply with the requirements of this document in matters of environmental protection. Vessels built prior to the entry into force of the convention need to be modernized to comply with its requirements. Transport ships on international voyages should be equipped with containers for collecting contaminated water and containers for collecting garbage.

The Oil Pollution Prevention Regulations take into account the need for surveys and inspections of large and medium-sized oil tankers and other vessels. The initial survey is carried out before the ship is put into service and includes a complete inspection of its structure in order to make sure that the structure, equipment, systems, and devices of the ship fully meet the requirements of Annex I to MARPOL 73/78. Periodic surveys are repeated at regular intervals, but not more than every five years. After the survey, oil tankers are issued International Oil Pollution Prevention Certificates.

According to the convention, any discharge into the sea of oil and oily mixture from ships is prohibited, except in special cases in which their limited discharge is allowed. Separately, the order of navigation of ships with oil in special regions - the Mediterranean, Baltic, Black, Red Seas, the Gulf of Aden and the Antarctic region - is stipulated.

To prevent the ingress of oil products into the sea in all ports and terminals where crude oil is loaded into oil tankers, as well as in the ports of ship repair, reception facilities of sufficient capacity are provided for discharging oil residues and oily mixtures, dirty ballast, washing water from tanks.

The rules for the prevention of pollution by sewage from ships prohibit the discharge of sewage into the sea, except for situations related to ensuring the safety of the ship or saving human life, as well as specially stipulated cases.

Trash Pollution Prevention Regulations from ships prohibit the dumping of all types of plastics into the sea, including synthetic ropes, synthetic fishing nets and plastic garbage bags. Discharge of food waste, as well as garbage in the form of paper products, rags, glass, metal, etc. allowed no closer than 12 nautical miles from the coast, and subject to strong crushing of such types of garbage – no closer than three nautical miles from the coast.

Practice shows that it is not possible to prevent pollution of the aquatic environment only through the use of various environmental technology and devices for processing and disposal of garbage on ships, therefore, part of the ship's waste must be disposed of on the shore using special reception facilities of ports. Thus, for the removal from ships of all types of food, household and operational waste (excluding fresh fish and its remains), port reception facilities should be used.

The rules for the prevention of air pollution from ships take into account that the sources of air pollution from ships are emissions from power plants of carbon oxides, sulfur and nitrogen, ozone-depleting substances, which are standardized by Annex VI to MARPOL 73/78. The rules stipulate that all diesel engines with a power of more than 130 kW must be monitored for the content of NO_r in exhaust gases and, based on the results of the control, must be accompanied by international documents.

For domestic water transport vessels (also railway diesel locomotives and industrial diesel engines), emissions of pollutants are regulated by GOST R 51249-99 “Marine, diesel and industrial diesels. Emissions of harmful substances with exhaust gases.

The maximum permissible values of emissions of harmful substances with exhaust gases of engines after overhaul are determined by calculation based on the data in Table. 4.1 using the correction factors given in table. 4.2

Table 4.1 - Values of emissions of harmful substances for new engines

Name standardized parameter	Purpose of the engine	The rate of specific weighted average emissions	
		Release before 2000 Production launch since 2000	
Specific weighted average emission of nitrogen oxides (N0/reduced to $N0_2$, g /(kW h)	Locomotive	18,0	12,0
	Industrial	16,0	10,0
	Ship	17,0	(17,0 – 9,8)
Specific weighted average emission of carbon monoxide (CO), g / (kWh)	Any	6,0	3,0
Specific weighted average emission of hydrocarbons (CH) reduced to CH_{85} , gDkWh)	Any	2,4	1,0

Specific weighted average emission of nitrogen oxides for ship engines:

a) at 130 rpm = 17 g / (kW · h);

b) in the frequency range 130 · 2000 min is determined by calculation, gDkW · h;

c) at a speed of > 2000 min = 9,8 g / (kW·h).

Table 4.2 - Correction factor values depending on the hazardous substance

Name of the harmful substance	Coefficient value
Carbon monoxide	1,20
Nitric oxide	0,95
Hydrocarbons	1,25

The technical regulations approved by the Government of the Russian Federation of February 27, 2008 No. 118 "On approval of the technical regulations" On requirements for motor and aviation gasoline, diesel and marine fuel, jet fuel and heating oil " handling of automobile and aviation gasoline, diesel and marine fuel, jet fuel from the point of view of their environmental safety. Fulfillment of these requirements on vehicles will ensure the lowest emission of toxic substances into the surrounding atmosphere with exhaust gases.

Special requirements to ensure the safety of the crew members during preparation for the flight and during the flight are set out in the Flight Operations Manual for the Il-86 aircraft Flight Operations Manual.

Aircraft crew members (hereinafter referred to as crew members), regardless of qualifications and work experience, must complete all types of labor safety briefing in a timely manner and in full (introductory, primary at the work place, repeated). Incase of interruptions in flight work for more than 60 calendar days, as well as in case of violation of the requirements of the labor protection instructions, members crews must undergo unscheduled briefings (individually or by the entire crew of the aircraft).

Persons who have not been instructed are not allowed to work.

During work, the crewmembers can be influenced mainly by the following hazardous and harmful production factors:

-aircraft moving through the aerodrome, special vehicles and self-propelled mechanisms;

-jets of exhaust gases from aircraft engines, as well as stones, sand and other objects trapped in them;

-air suction streams moving at high speed (zone of nozzles of aircraft engines);

-rotating propellers of parked aircraft and helicopters;

-protruding parts of the aircraft and its equipment (structural elements of engines, sharp edges of antennas, uncovered hatches, hatches, etc.);

-increased sliding (due to icing, moisture and oiling of the surfaces of the aircraft, folding ladders, ladders, parking space and airfield cover);

-items located on the surface of the aircraft parking area (hoses, cables, ground cables, etc.);

-performing work close to unshielded height differences (on a stepladder, ladder, plane, at an open hatch, front door, etc.);

-electric current, which, in the event of a short circuit, can pass through the human body;

-increased noise level from operating aircraft engines and APU;

-high or low temperature and humidity;

-discharges of static electricity;

-insufficient illumination of the working area, aircraft parking area, apron;

-fire or explosion.

To monitor the state of health, crewmembers must annually undergo a medical examination by a medical-flight expert commission (VLEK) and periodic medical examinations in accordance with the established procedure. Crewmembers who have not passed the periodic medical examination and annual examination at VLEK are not allowed to fly.

Crew members must wear special clothing, footwear and other personal protective equipment in accordance with the current Regulations.

In the event of illness, poor health, insufficient pre-flight rest (when outside the base), the crew members must report their condition to the commander of the aircraft and seek medical help.

If an accident occurs with a crew member, then he needs to provide medical assistance and report the incident in the prescribed manner to organize an investigation of this case in accordance with the current Regulation on the procedure for investigating and recording accidents at work.

Crew members should be able to provide first aid, use anon-board first aid kit.

Crew members must comply with the working hours and rest hours established for them: norms of flight time, pre-flight and post-flight rest, rules of conduct while on duty, in reserve, etc.

To prevent the possibility of fires and explosions, crew members must themselves comply with fire and explosion safety requirements and prevent violations by passengers (do not smoke in the aircraft parking area , do not use open fire, etc.).

Crew members who fail to comply with OSH instructions may be subject to disciplinary action; if the violation is related to the infliction of material damage to the enterprise, the crew members may be held liable in accordance with the established procedure.

4.2. Safety requirements before departure during pre-flight preparation

Crew members are required to undergo a medical examination before the flight. When flying abroad, a pre-flight medical examination is not carried out. The commander of the aircraft is responsible for keeping the crew members of good rest.

When moving around the aerodrome, crew members must observe the following rules:

-walk only on specially designed routes.

-to avoid accidents from collisions with vehicles and self-propelled mechanisms while walking, be careful, especially in difficult meteorological conditions (rain, fog, snowfall, ice, etc.) and at night; it should be remembered that in conditions of aircraft noise, sound signals from vehicles and the noise of a running engine of an approaching vehicle or self-propelled mechanism may not be heard.

-exercise caution in the vicinity of high-risk zones (zones of operating aircraft engines, rotation of aircraft propellers, helicopter main and tail rotor propellers, radiation of antennas of ground and airborne radio equipment, taxiing and towing of aircraft, maneuvering special vehicles and mechanization equipment near an aircraft, refueling an aircraft with fuels and lubricants, loading -unloading works, etc.), as well as on the carriageway; pay attention to irregularities and slippery places on the surface of the aerodrome and avoid movement on them. It is dangerous to be at a distance: less than 50 m in the direction of the gas exit from the engine; less than 10 m in front of the engine air intake; less than 20 m when operating onboard radar stations.

During the pre-flight inspection of the aircraft, it is necessary to:

-use serviceable stepladders and ladders provided for the Il-86 aircraft. Special care should be taken in adverse weather conditions (eg rain, snow). You cannot jump off a ladder or walk down a few steps.

-be careful when moving around the parking lot so as not to stumble or bump into hoses, cables, cables, sleeves, thrust blocks, carts, cylinders, etc.

-to avoid head injury, be careful when moving under the fuselage near low-lying parts of the aircraft (for example, engine nacelles).

-to exclude the causes of accidents with members crews should: be careful inside the aircraft to avoid injury from uncovered panels and doors and falls into uncovered hatches; do not hold on to the openings of open doors inside the aircraft to avoid possible pinching of fingers; when going down the ladder, button up your coat or raincoat, hold onto the handrails.

In the process of pre-flight preparation, each crew member must be guided by the requirements of the Airplane Flight Manual, including:

-Flight engineer: when inspecting the aircraft from the outside (in accordance with the established route): make sure that there are necessary fire extinguishing equipment near the aircraft, thrust blocks are installed under the wheels of the main landing gear, current collectors on the landing gear have contact with the ground, the aircraft is grounded; check that there are no foreign objects under and near the aircraft; make sure the airplane exit ramps are clean. when inspecting inside the aircraft: make sure that all access hatches, floor and ceiling panels are closed; while it follows keep in mind that uncovered hatches and panels have caused a significant number of crew accidents; inspect the trunks, aisles in the passenger compartments and the cockpit and make sure that there are no foreign objects in them; make sure the doors are closed, including emergency and cargo doors; make sure that the rescue equipment and floating craft are on board and securely fastened, onboard hand-held fire extinguishers are in place, and onboard medical kits are complete; check the presence of oxygen masks and oxygen in the system; make sure that the seat is securely locked, the seat belts are not damaged and the seat belt buckle is working (if necessary, adjust the seat and the length of the seat belts); check the pockets of the seats to avoid injuries to the hands from the stabbing and cutting objects left.

-Cockpit-pilot: make an external inspection of the cockpit, then take your workplace, make sure that the seat is securely locked, the seat belts are not damaged and the seat belt buckle is working (if necessary, adjust the seat and the length of the seat belts); check for smoke goggles, oxygen masks and oxygen in the system.

-Aircraft commander: accept reports from the crew members on the readiness of the aircraft and its equipment for flight; inspect the cab and make sure there are no foreign objects; take your workplace, make sure that the seat is securely locked, the seat belts are not damaged and the seat belt buckle is working (if necessary, adjust the seat and the length of the seat belts).

When refueling the aircraft, the following requirements must be met:

-before refueling, check that the aircraft and the tanker are grounded and that they are connected with a cable to equalize the potential of static electricity.

-ensure that the necessary fire extinguishing equipment is available at the aircraft parking area.

-during the refueling of the aircraft, it is prohibited to: - perform any types of maintenance of the aircraft, as well as loading and unloading operations and treatment of the aircraft with an anti-icing liquid "Arctic"; connect and disconnect the aerodrome power supply to the on-board electrical network; use open fire and lamps that do not meet fire and explosion safety requirements; continue refueling in the event of an impending thunderstorm.

4.3. Safety requirements during the flight mission

The main condition for ensuring the safety of crew members in the process of performing a flight mission is their compliance with the requirements of the NPP and RLE.

The aircraft can only be towed when the pressure in the braking system is within the specified limits.

During the towing of the aircraft, the crew members must be at their workplaces and, if necessary, take measures to timely stop the aircraft.

When towing an aircraft at night and in poor visibility conditions, turn on the flash beacon, air navigation and side lights and make sure that the headlights and side lights on the towing vehicle are also on.

The speed of towing on a dry concrete track "nose" forward is allowed no more than 10 km/h, "tail" forward - no more than 5 km/h, near obstacles no more than 5 km/h.

Engine start-up can be started only after obtaining permission from the air traffic controller, aircraft technician, launching the aircraft, and reports of the crew members on the readiness of the aircraft for flight.

Before starting the engines, make sure that:

-the folding ladders are removed.

-the ground train launching the aircraft is ready to start the engines.

-the aircraft is on the parking brake.

-ladders and other equipment on both sides of the aircraft are removed to a distance that ensures safe starting and testing of engines;

Before taxiing out, the aircraft technician must be instructed to disconnect the airfield power supply.

Taxi speed should be maintained depending on taxiway conditions, visibility conditions and the presence of obstacles.

Taxiing near obstacles, in areas of heavy traffic of aircraft, special vehicles, people, as well as with limited visibility should be performed at a speed that ensures the timely stop of the aircraft.

During the flight, while at their workplaces, the crew members must be fastened to the seats of the seats with seat belts.

Crew members should not touch the exposed leads of open antennas for HF radios.

Use insulated tweezers when replacing fuses; fuses designed for high amperage must not be used.

If it is necessary to check the presence of voltage in the electrical circuit, it is not allowed to use the "spark" method.

Crew members must ensure that electrical panels, junction boxes and terminal boxes are always closed.

When flying for more than 4 hours for preventive purposes, you should breathe oxygen for 10 minutes every 2 hours of flight, as well as before descent.

When using oxygen equipment, crew members must ensure that their hands are clean and free from traces of grease.

Each time the crew members leave the cockpit, they must close the front door with a lock and open it only on a prearranged signal.

When passing through the passenger cabins, crew members should be careful not to trip over possible folds on the carpet, as well as on passengers' carry-on luggage; take measures to eliminate these violations.

The time and sequence of meals by the crew members during the flight shall be set by the aircraft commander. Both pilots are not allowed to eat at the same time.

When transporting weapons on board the aircraft, one should be guided by the aviation security requirements set out in the regulatory documents for the inspection of passengers, crew members of civil aircraft, service personnel, carry-on luggage, baggage, cargo, mail and onboard food supplies.

When taxiing into the parking lot after the flight, the crew members must observe the obstacles and promptly report this to the aircraft commander in order to avoid a collision.

4.4. Safety requirements in emergency situations

In the event of a fuel spill during refueling on the aircraft surface or parking space, refueling should be stopped until the spilled fuel is completely removed. At the same time, the engines can be started no earlier than 10 - 15 minutes after the spilled fuel has been removed from the surface of the aircraft and its parking area.

In the event of a fire on the ground in an aircraft, the crew members must immediately inform the ATC service about this, and at the same time begin to evacuate passengers. When extinguishing a fire, in addition to on-board equipment, it is necessary to additionally use ground-based fire extinguishing equipment available at the aerodrome.

In flight, if smoke, burning or an open flame is detected in the pilot's or passenger cabin, as well as in the luggage compartments, it is necessary to immediately report this to the aircraft commander and start searching for and extinguishing the fire source using hand-held fire extinguishers and other available means. The fire must be reported to the ATC.

If smoke appears in the cockpit, all crew members should wear smoke protection equipment (oxygen masks and smoke goggles).

In the event of a fire in any consumer of electrical energy, it is necessary to immediately de-energize it.

Crew members must prevent the occurrence of panic among passengers.

If the fire is not extinguished in flight, then after the aircraft has landed, emergency means must be used to evacuate passengers from the aircraft to a safe distance.

The actions of the crew members in the event of an emergency landing of the aircraft and in other special cases must comply with the requirements of the Airplane Flight Manual.

4.5. Safety requirements at the end of the flight

Do not open the front doors and kitchen doors when there is overpressure in the cabin. To equalize the pressure in the cockpit with the external co-pilot, open the window. Before opening the entrance doors, the flight engineer needs to ensure that the "Open door" lights above the internal controls are on.

You can go out onto the ladder only after the ladder has been fully unfolded, the halves of the ladder in their joint on the locks and the green light-signal board "Ladder released" lights up.

Crew members should leave the aircraft on the exhaust ladder only after the engines have come to a complete stop; it is not allowed to go down the ladder through several steps; to avoid slipping (especially in rain and snow), hold on to the handrail while descending the ladder.

The flight engineer must ensure that:

-No cutting or piercing objects are left in the pockets of the crew seats.

-Thrust blocks are installed under the landing gear wheels, the aircraft is grounded.

When performing an external post-flight inspection of the aircraft, it is necessary to observe the precautions described in paragraph 4.3. of this Model Instruction.

Conclusions to the part

At the moment, it is almost impossible to say that there are no problems in aviation - there are many issues related to economics, safety and ecology. All these problems are solvable, but it takes time. The world does not stand still: everything that existed before is being modernized or deteriorating, and something completely new comes to replace the old. The same thing happens in aviation. Aviation kerosene will soon be replaced by new biofuels, aircraft engines will become large, but light in weight; composite materials will soon push metal and aluminum "off the pedestal". I have come to the conclusion that while aviation is harmful to the environment, its popularity will continue to grow and grow, so solving all the current problems should not take long.

PART 5. LABOUR PROTECTION

5.1. Requirements for passenger seats of an airliner

Occupational health and safety systems in aircraft equipment manufacturing have undergone changes to reflect the evolutionary health and safety process within the traditional manufacturing enterprise. The structure of the health and safety programs looked like this: the management of the companies headed the health and safety programs, and the management was built according to the traditional hierarchical management scheme (directive-control). Major aviation and aerospace companies had a professional occupational health and safety staff (industrial sanitation, health care, occupational safety engineers, and technicians). They worked with line managers to address a variety of safety concerns for workers in production processes. This approach to linear workplace health and safety programs, with the production manager in charge of day-to-day safety with the support of a central group of health and safety professionals, has been a dominant model since the inception of the industry. As a result, many occupational health and safety systems have become systems that meet requirements rather than those aimed at preventing injury and illness. OSH programs, formerly integrated into line management, have lost some of their effectiveness as the complexity of regulations has forced a more core of OSH professionals to rely on all safety program matters and partially removed responsibility and accountability from line managers.

In line with the tendency all over the world to pay more and more attention to total quality management, the emphasis is again shifting to production sites. Aircraft cabin equipment manufacturers are deploying programs that include safety as an integral part of a reliable manufacturing process. Compliance with standards fades into insignificance, meaning there is a need to focus on process reliability when prevention of injury and illness becomes the main goal, and compliance with regulations or their goals will be achieved by adopting a reliable process. The aviation industry as a whole now has some traditional programs, procedural programs, and emerging behavior-based programs. Regardless of the specific model, the programs that have shown the greatest success in preventing injury and illness require three important components:

1) Explicit involvement of both management and employees,

2) Clearly articulated expected results in the prevention of injury and disease,

3) Accountability and reward systems based both on the measurement of outcomes (such as data on injuries and illnesses) and on percentages (such as percentage of safe behavior) or other proactive prevention measures that are weighted equally with other important goals of the organization.

All of the aforementioned systems lead to a positive safety culture, with leadership leading by example, with the full involvement of workers in both process design and improvement.

The manufacture of aircraft equipment is potentially associated with many serious hazards simply due to the big size and complexity of the products manufactured and the variety and variability of the manufacturing and assembly processes used. Unintentional exposure to such hazards or inadequate protective measures can lead to immediate serious injury. Table 5.1 provides an overview of known security threats in the aviation industry. Direct injury can be immediate injury can be caused by: a fallen control unit placed under a rivet on the back, or other fallen objects; overturning on uneven, slippery or clogged work surfaces; falls from overhead drawbridges, racks or large scaffolding; contact with ungrounded electrical equipment, hot metal objects and concentrated chemical solutions; contact with blades, drills and cutters; getting or pinching hair, hands or clothes on machines, presses; splinters, particles and scale, chemical treatment and straightening; bruises and cuts from collisions with parts and structural elements of the aircraft during production.

Table 5.1 - Hazards types and examples

Hazard Type	Typical examples	Possible consequences
Physical falling objects. Moving equipment. Dangerous heights. Sharp objects. Mechanisms of movement. Garbage in the air. Heated elements. Cast iron, scale, slag Electrical equipment. Fluid under pressure. Atmospheric pressure changed. Extreme temperatures. Noise from the engine. Ionizing radiation. Non-ionizing radiation. Work surfaces. Ergonomic. Work in a confined space. Application of physical force of vibration. Human-machine interaction. Lifting, carrying, trolleys, hand tools, electrical installation. Repetitive movement.	Riveting pistols, counter bars, fasteners, hand tools. Car lifts, cranes. Stairs, racks, prefabricated beams. Blades, drills, cutters. Sandblasting, sawing, scanning, chemical treatment. Metals in the process of hot processing, welding. Welding, gas cutting, casting. Hand tools, cords, lanterns, junction boxes. Hydraulic systems, vacuum oil and spray guns. Airtightness tests of aircraft, autoclaves, test chambers. Work with hot metal, foundry production, work with cold metal. Riveting, engine testing, high-speed drilling, jackhammers. Industrial radiography, accelerators, radiation research. Welding, lasers, radars, research. Spilled lubricants, scattered tools, hoses and cables. Aircraft fuel tanks, wings. Lifting, carrying, trolleys, hand tools, electrical installation. Riveting, sandblasting. I work on machines, installation work in an awkward position. Data entry, design work, production of composite materials.	Concussion, head injury. Clogged places, fractures, cuts. Multiple serious injuries, death. Torn, stab wounds. Amputations, exfoliation, fragmentation. Eye contact with foreign bodies, damage to the cornea. Burns, tumors, changes in pigmentation. Serious burns to the skin, eyes and ears. Concussion, sprains, burns, death. Eye injuries, serious subcutaneous injuries. Injuries to ears, sinuses and lungs, bends / bends. Overheating of the body, frostbite. Temporary or permanent hearing loss. Infertility, cancer, radiation sickness, death. Corneal burns, cataracts, retinal burns, cancer. Bruises, lacerations, sprains, fractures. Oxygen starvation, fear of confined space, anesthesia, death. Severe fatigue, skeletal muscle injuries, carpal tunnel syndrome. Skeletal muscle injury, carpal tunnel syndrome. Skeletal muscle injury. Carpal tunnel syndrome, skeletal muscle injury.

5.2. Ergonomics in manufacturing industry

Aircraft manufacturers have a long history of using the human factor in the development of systems critical to their products. The cockpit became one of the most well-studied areas in product development history, with ergonomics engineers working to optimize flight safety. Today, the fast-growing branch of ergonomics related to injury and disease prevention is a continuation of early work on human factors. The industry has processes involving the use of physical force, awkward postures, repetition, stress and vibration caused by mechanical contact. This impact can be exacerbated when working in confined spaces such as inside fenders or fuel tanks. To solve these problems, the industry uses ergonomics specialists in the design of products and processes, as well as specialists in "participatory ergonomics" (ergonomics of participation), when teams of production specialists, managers and toolmakers and technologists work together to reduce ergonomic risks in their processes. In the aircraft equipment industry, one of the key ergonomic issues is skeleton assembly workshops where many hand tools are required and force is required to grip. Most of the tools are replaced by pneumatic tools that are suspended on balancers if they are heavy. Height-adjustable workstations, adaptable to both men and women, provide the ability to sit or stand. Work is organized in cells in which each worker performs a number of different tasks to reduce fatigue in one muscle group. On production lines for wing assemblies - another key area - pads are needed for tools, parts or workers to reduce stress from mechanical contact in confined spaces. The wing assembly line also uses adjustable height work platforms instead of stepladders to minimize falls and keep the worker in a neutral position when drilling or riveting. Riveting tools are still a significant problem as they present vibration and stress risks. To solve this problem, low recoil riveting tools and electromagnetic riveting methods are being introduced, but due to the characteristics of these products and some practical limitations of such methods in manufacturing processes, they are not a universal panacea.

With the introduction of composites for weight and performance reasons, hand stacking of composite plies also poses potential ergonomic hazards due to the widespread use of hands to form, cut and process the material. To mitigate this risk, additional tools with different handle sizes and some automated processes are being introduced. Adjustable tools and machines are also used to work in neutral positions. Assembly processes bring with them many problems of awkward posture and manual labor, which are often solved by participatory ergonomics processes. Hazard reduction is achieved by the wider use of lifting mechanisms, where it is justified, by changing the sequence of work, as well as by introducing other improvements in the processes aimed not only at eliminating ergonomic risks, but also at increasing the productivity and quality of products.

Noise as an unfavorable factor in the production environment is present in the aviation industry. The impact of noise on the human body is mainly related to the use of new, high-performance equipment, mechanization and automation of production processes, the transition to high speeds during the operation of machines and units. Noise sources can be engines, pumps, compressors, turbines, pneumatic tools, hammers, machines and other installations that include moving mechanisms and rotating parts.

In the conditions of production the most affected by noise are engine testers, riveters, cutters, pilots, shop workers and others.

In production, noise can be constant and intermittent when its level during the work shift (8 hours) changes by more than 5 dB. Volatile noise is divided into intermittent, pulsed and fluctuating, when the noise level is constantly fluctuating. The degree of negative impact of noise depends on the strength and frequency of sound, the duration of its action, the physical and mental state of man. The harmful effects of industrial noise are manifested in the form of specific damage to the hearing organs, and in the form of disorders of many other organs, especially the central nervous system. Intense industrial noise leads to partial or complete hearing loss. Changes in hearing occur when the noise is more than 80 dB and occur within 3-5 years, depending on the physical condition of the worker. Signs of deafness are poor perception of whispering and tinnitus. Prolonged (more than 10 years) exposure to noise above 90 dB on the worker can cause not only deafness, but also absolute hearing loss due to degeneration of sensitive cells of the inner ear due to their overexertion. Such hearing disorders in employees are classified as irreversible.

Under the influence of noise, changes occur not only in the auditory center of the nervous system, but also in those departments that regulate such vital functions as blood circulation, respiration, digestion, hematopoiesis, motor activity and others. The negative impact of noise on the employee's nervous system is manifested in headaches, insomnia, fatigue, increased sweating, tremors of fingers and hands, increased irritability, memory and attention disorders, and the cardiovascular system - in pain in the heart, decreased frequency pulse, hypotension or hypertension. Normal noise background increases the level of excitement and has a positive effect on human performance.

Conclusions to the part

The main areas of noise control in the workplace are the use of low-noise technological processes and equipment, equipping noisy equipment with remote control, compliance with the rules of technical operation, conducting scheduled preventive inspections and repairs, timely preliminary (during employment) and periodic activities) medical examinations of workers engaged in heavy work, work with harmful or dangerous working conditions, the introduction of physiologically justified modes of work and rest; use of personal protective equipment (headphones, noise-canceling inserts, noise-canceling helmets, earplugs, etc.).

GENERAL CONCLUSION

The presented thesis for the masters degree thesis “Passenger seat design for a short range passenger aircraft” is devoted to the actual problem for aviation industry and for airliners. To provide flight safety if the key strategy of ICAO, FAA and EASA regulations and standarts. According to these requirements all passenger seats have to be certified on HIC with the video-demonstration of crash test - full-scale dynamic tests of block of seats with the antromorphy test dummy with sensor to control the load factor and acceleration. The tasks of the tests are: to ensure HIC less 1000, to check the strength of the seats attachment to the floor, to check strength of belts and to prevent the strike with protruding parts. One of the effective decisions to ensure an acceptable level of injury for passengers is the implementation of belts with special airbags. Also the new smart materials for the passenger frame could also reduce the level of HIC.

In the diploma work the new decision for passengers safety during the emergency landing is presented. The human body could withstand the load factor in longitudinal direction close to 12g force, but the more dangerous load factor is in vertical strike, maximum at 3g force.

The main geometrical parameters of the main parts of the designing passenger aircraft were determined. The general view and fuselage layout are presented with the accommodation of 50 passengers in a cabin. All values obtained meet the requirements for short-haul passenger aircraft. The center of gravity calculation for the flight with maximum payload and for the flight at maximum range has been completed.

The task of the diploma thesis is the conceptual design of the passenger’s seat support (or legs) with the shock absorber for one of the strut. It will reduce the injury of human body during vertical strike in rough landing. The presented investigation could be useful for manufacturers of passenger’s seat or airline and other aviation companies.

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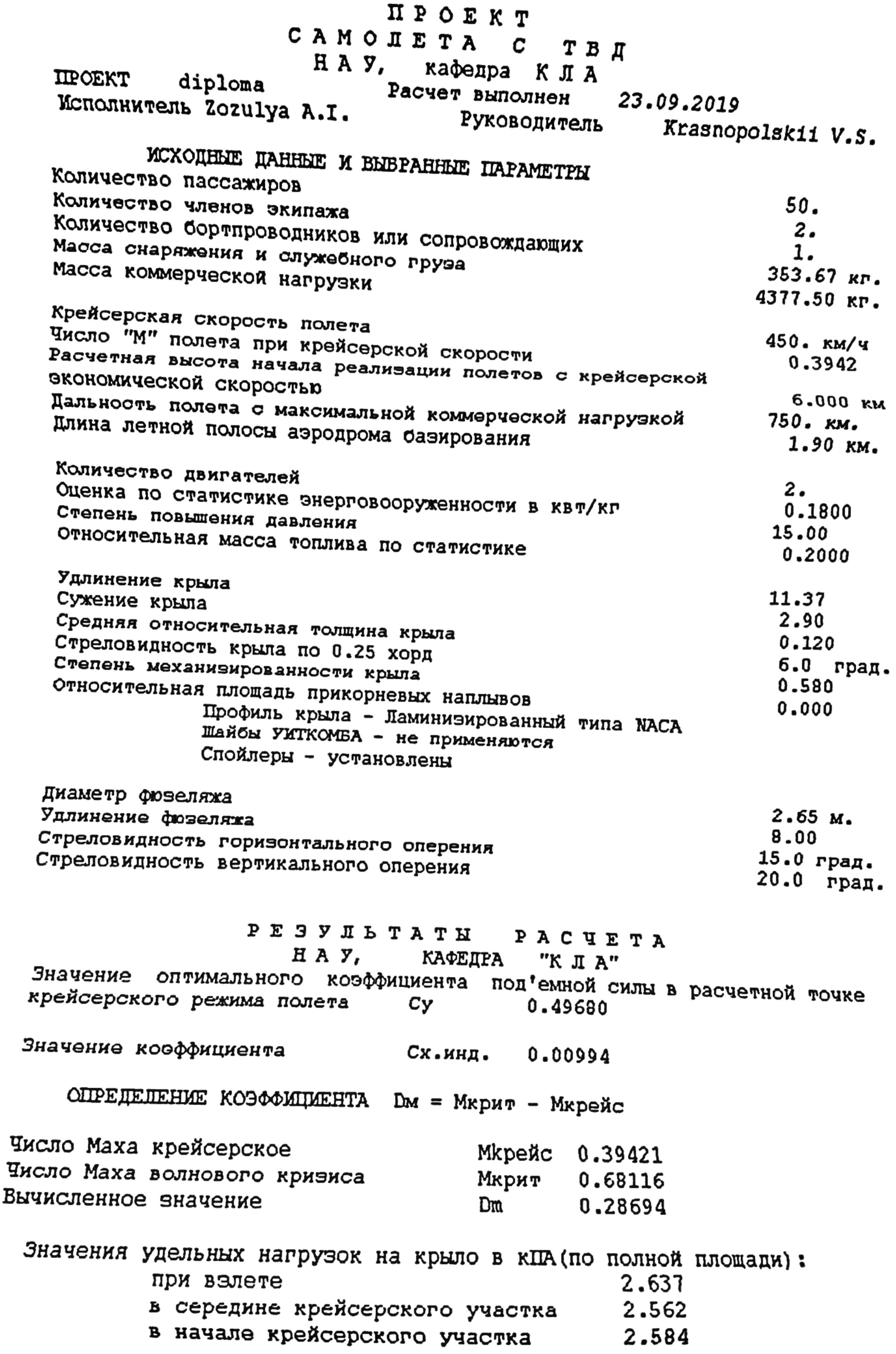
Appendix A



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                          П Р О Е К Т
                    С А М О Л Е Т А   С   Т В Д
                       Н А У,  кафедра  К Л А
ПРОЕКТ    diploma            Расчет выполнен    23.09.2019
Исполнитель Zozulya A.I.           Руководитель     Krasnopolskii V.S.

          ИСХОДНЫЕ ДАННЫЕ И ВЫБРАННЫЕ ПАРАМЕТРЫ
Количество пассажиров
Количество членов экипажа                                      50.
Количество бортпроводников или сопровождающих                  2.
Масса снаряжения и служебного груза                            1.
Масса коммерческой нагрузки                                  353.67 кг.
                                                            4377.50 кг.

Крейсерская скорость полета
Число "М" полета при крейсерской скорости                    450. км/ч
Расчетная высота начала реализации полетов с крейсерской      0.3942
экономической скоростью
                                                              6.000 км
Дальность полета с максимальной коммерческой нагрузкой       750. км.
Длина летной полосы аэродрома базирования
                                                              1.90 км.

Количество двигателей
Оценка по статистике энерговооруженности в квт/кг             2.
Степень повышения давления                                    0.1800
Относительная масса топлива по статистике                    15.00
                                                              0.2000

Удлинение крыла
Сужение крыла                                                11.37
Средняя относительная толщина крыла                           2.90
Стреловидность крыла по 0.25 хорд                             0.120
Степень механизированности крыла                              6.0  град.
Относительная площадь прикорневых наплывов                    0.580
               Профиль крыла - Ламинизированный типа NACA     0.000
               Шайбы УИТКОМБА - не применяются
               Спойлеры - установлены

Диаметр фюзеляжа
Удлинение фюзеляжа                                            2.65 м.
Стреловидность горизонтального оперения                       8.00
Стреловидность вертикального оперения                        15.0 град.
                                                             20.0  град.


                 Р Е З У Л Ь Т А Т Ы   Р А С Ч Е Т А
                     Н А У,     КАФЕДРА   "К Л А"
Значение  оптимального  коэффициента  под'емной силы в расчетной точке
крейсерского режима полета       Су        0.49680

Значение коэффициента            Сх.инд.    0.00994

    ОПРЕДЕЛЕНИЕ КОЭФФИЦИЕНТА  Dm = Mкрит - Mкрейс

Число Маха крейсерское                  Мкрейс  0.39421
Число Маха волнового кризиса            Мкрит   0.68116
Вычисленное значение                    Dm      0.28694

Значения удельных нагрузок на крыло в кПА(по полной площади):
            при взлете                           2.637
            в середине крейсерского участка      2.562
            в начале крейсерского участка        2.584
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   Значение коэффициента сопротивления фюзеляжа и гондол       0.00985
   Значение коэфф. профиль. сопротивления крыла и оперения     0.00995
   Значение коэффициента сопротивления самолета:
             в начале крейсерского режима                    0.03328
             в середине крейсерского режима                  0.03319

    Среднее значение Су при условном полете по потолкам      0.49680
    Среднее крейсерское качество самолета                   14.96679

  Значение коэффициента Су.пос.                                   1.556
  Значение коэффициента ( при скорости сваливания ) Су.пос.макс.  2.334
  Значение коэффициента ( при скорости сваливания ) Су.взл.макс.  2.074
  Значение коэффициента  Су.отр.                                  1.493
  Энерговооруженность в начале крейсерского режима                0.100
  Стартовая  энерговооруженн. по условиям крейс. режима No.кр.    0.145
  Стартовая энерговоруж. по условиям безопасного взлета No.взл.   0.146

 Расчетная энерговооруженность самолета   No   0.150

 Отношение    Dn = No.кр / No.взл         Dn   0.996

        УДЕЛЬНЫЕ РАСХОДЫ ТОПЛИВА ( в кг/кВт*ч ):
 взлетный                                                0.3034
 крейсерский (характеристика двигателя)                  0.2603
 средний крейсерский при заданной дальности полета       0.2611


       ОТНОСИТЕЛЬНЫЕ МАССЫ ТОПЛИВА:
            аэронавигационный запас        0.02030
            расходуемая масса топлива      0.06738


                   ЗНАЧЕНИЯ ОТНОСИТЕЛЬНЫХ МАСС:
            крыла                            0.15047
            горизонтального оперения         0.01799
            вертикального оперения           0.01782
            шасси                            0.05217
            силовой установки                0.11394
            фюзеляжа                         0.11076
            оборудования и управления        0.16761
            дополнительного оснащения        0.00294
            служебной нагрузки               0.02082
            топлива при  Lрасч.              0.08769
            коммерческой нагрузки            0.25771

          Взлетная масса самолета "M.o" =   16986. кГ.
     Потребная взлетная мощность двигателя    1276.8 kВт

Относительная масса высотного оборудования и
противообледенительной системы самолета                  0.0277
Относительная масса пассажирского оборудования
(или оборудования кабин грузового самолета)              0.0206
Относительная масса декоративной обшивки и ТЗИ           0.0133
Относительная масса бытового (или грузового) оборудования 0.0082
Относительная масса управления                           0.0129
Относительная масса гидросистем                          0.0304
```

Относительная масса электрооборудования	0.0300
Относительная масса локационного оборудования	0.0047
Относительная масса навигационного оборудования	0.0070
Относительная масса радиосвязного оборудования	0.0035
Относительная масса приборного оборудования	0.0082
Относительная масса топливной системы (входит в массу "СУ")	0.0025
Дополнительное оснащение:	
Относительная масса контейнерного оборудования	0.0000
Относительная масса нетипичного оборудования [встроенные системы диагностики и контроля параметров, дополнительное оснащение салонов и пр.]	0.0029

ХАРАКТЕРИСТИКИ ВЗЛЕТНОЙ ДИСТАНЦИИ

Скорость отрыва самолета	189.97 км/ч
Ускорение при разбеге	1.72 м/с*с
Длина разбега самолета	806. м.
Дистанция набора безопасной высоты	409. м.
Взлетная дистанция	1215. м.

ХАРАКТЕРИСТИКИ ВЗЛЕТНОЙ ДИСТАНЦИИ ПРОДОЛЖЕННОГО ВЗЛЕТА

Скорость принятия решения	180.47 км/ч
Среднее ускорение при продолженном взлете на мокрой ВПП	0.17 м/с*с
Длина разбега при продолженном взлете на мокрой ВПП	1552.15 м.
Взлетная дистанция продолженного взлета	1921.90 м.
Потребная длина летной полосы по условиям прерванного взлета	2002.81 м.

ХАРАКТЕРИСТИКИ ПОСАДОЧНОЙ ДИСТАНЦИИ

Максимальная посадочная масса самолета	16511.	кг.
Время снижения с высоты эшелона до высоты полета по кругу	12.0	мин.
Дистанция снижения	15.05	км.
Скорость захода на посадку	198.65	км/ч.
Средняя вертикальная скорость снижения	1.68	м/с
Дистанция воздушного участка	378.	м.
Посадочная скорость	187.13	км/ч.
Длина пробега	573.	м.
Посадочная дистанция	950.	м.
Потребная длина летной полосы (ВПП + КПБ) для основного аэродрома	**1587.**	м.
Потребная длина летной полосы для запасного аэродрома	**1350.**	**м.**

ПОКАЗАТЕЛИ ЭФФЕКТИВНОСТИ САМОЛЕТА

Отношение массы снаряженного самолета к массе коммерческой нагрузки	2.5284
Масса пустого снаряженного с-та приход. на 1 пассажира	221.36 кг/пас.
Относительная производительность по полной нагрузке	155.43 км/ч
Производительность с-та при макс. коммерч. нагрузке	1669.4 т*км/ч
Средний часовой расход топлива	581.991 кг/ч
Средний километровый расход топлива	1.53 кг/км
Средний расход топлива на тоннокилометр	348.626 г/(т*км)
Средний расход топлива на пассажирокилометр	28.6146 г/(пас.*км)
Ориентировочная оценка приведен. затрат на тоннокилометр	1.3636 $/(т*км)