Design and calculation of take-off and landing gear for airplane with take-off weight of 2 000 kg

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The thesis describes the design of landing gear for aircraft weighing to 2,000 kg. Explaining basic terms related to the issue and concept of the chassis design for the proposed aircraft, classified according to regulation CS-23. A separate bonding calculation is carried out by Creo Parametric CAD program. For designed airplane was chosen as the best variant type of three-gear-wheel landing gear with the front landing gear.

1 INTRODUCTION

Landing and takeoff system is one of the main parts of the airframe for every aircraft. Therefore, there are different variations of chassis, whose role is to ensure not only safe takeoff and landing, but also in many cases, to move along the ground.

My task is to propose a landing and take-off device. The main task is to focus on the choice of the appropriate type of chassis and make the calculation of the proposed bonding structures. As this work focuses on the development of a preliminary study, its role is not to make the retractable mechanism design and control systems associated with the brakes, shooting the front chassis legs eventually differential braking and so on.

In addressing the issue, I chose the method of stress analysis using Creo Parametric CAD program. The advantage of this method is to simplify the calculation procedure for sizing the various parts of the chassis. After selecting the most satisfactory design the material analysis was carried out, in which is a choice of suitable materials. The result of the above points is a 3Dmodel of the front and main gear legs created CAD program. Model results is the following operating loads and loads calculation, calculated as prescribed in CS-23, which falls within the proposed aircraft.

2 ANALYSES OF THE CURRENT STATE AND THE SELECTION OF CONFIGURATION

2.1 Purpose and requirements of landing gear

Landing gear enables to aircraft, the State on the ground, taxiing to the runway for a particular run of the takeoff and landing runway. The chassis for the flight is over-weight, which does nothing to improve the flight characteristics and performance of the aircraft. Nevertheless, to ensure the take-off and landing is not required use the chassis, which must meet several requirements.

The basic requirements that must fulfill the landing gear include:

- Sufficient strength and rigidity,

- Minimum dimensions,

- Minimum weight,

- Ability to assume the kinetic energy of the aircraft and dampen it,

- The ability to slow down the aircraft taxiing and landing,

- Reduction in the intensity of impact upon landing,

- Adequate levels of reliability and fatigue life,

- The possibility of easy operation, maintenance, and repair[1].

2.2 Types of landing gear

From the conceptual layout there are 3 basic types of chassis.

Landing gear with tail wheel - the main chassis is positioned forward of the aircraft, which is complemented by the tail wheel, it is located on the rear fuselage and is either freely rotating or directors.

Landing gear with the front landing gear - the main chassis in this case is located in the center of gravity of the aircraft and is complemented by front leg, which is located on the forward fuselage.

Tandem configuration - the main chassis is from the center of gravity of the aircraft and usually occurs by the auxiliary chassis mounted on the wings[3].

2.3 Construction of undercarriage

When designing the landing gear is mainly based on weight and size of aircraft. The primary parameter is the mass but which, together with a declining rate, the total kinetic energy of an aircraft, which will need to absorb the landing.

Most modern aircraft use the main undercarriage with two legs. For airplanes with a heavier weight is required more wheels for adequate energy absorption during landing. The lower weight category aircraft are usually equipped with a main gear legs with only one wheel.

Basic designs of chassis:

- Spring chassis
- Second Telescopic chassis
- Third Lever chassis [2].

Spring suspension

This type is the simplest type of solution that is used in practice. It consists of a straight or shaped springs or beam whose one end is firmly attached to the bottom or side of the airframe, while at the other end is fixed to the wheel brake. The body chassis can be made from steel, titanium alloys or composites. It captures and transmits the total load, which occurs during taxiing, takeoff and landing. In addition, it provides damping oscillatory motion but only to a limited extent[4].

Telescopic chassis

Telescope chassis are used on the sport aircraft and aircraft with a weight greater than the transport aircraft. The advantage of this solution is that the muffler is located directly in the body and, if retractable undercarriage variant is needed less space in the wings of the body falls, which is related to lower design complexity. Another of the advantages is the relatively low weight compared to a small lever drag. The disadvantage is again high foot building height, to achieve the best effect of shock. Their sense is also reflected in low efficiency of silencing suppressors from the horizontal forces, more friction in the cuff which is derived from the reduction in reliability and durability[4].

Leveraging chassis

The second type is the most commonly used design. The basic characteristic is that, unlike the previous type of muffler is located outside the undercarriage legs and wheel is attached to the lever. Advantages of the selected type lie in a relatively large stroke in a small chassis, and transmission of lateral forces on the chassis, which is transmitted through the lever body and chassis. Shock is stressed only the axial force thereby significantly extending the life of seals. The disadvantages are primarily higher weight, larger size, complex structure that requires a relatively larger space in the trunk respectively wing and creates more resistance [4].

2.4 Parts of the undercarriage

The chassis itself consists of a set of several parts, which are described in the following paragraphs. Described below do not include chassis parts.

- Wheel - tires, brakes, anti-lock device.

- Shock absorber

- Chassis, undercarriage legs.

- Ancillary equipment - retractable gear, locking features for extreme positions, the side shock oscillations, kinematics filming wheel cutters, gear position indication.

2.5 Characteristics of the proposed airplane

The requirements that were identified in the assignment, was chosen from a few aircraft to compare to choose the best option. The aircraft should meet several requirements such as maximum flight weight of 2,000 kg, the number of passengers (4-6), with a range of about 2000 km. Cruising speed is around 300 kmh-1, while the aircraft is powered by two turboprop engines TP 100 with takeoff power 180 kW (138kW permanent). The airplane then described the most desired parameters close to Vulcanair VR.

3. DRAFT CONCEPT OF THE LANDING AND TAKE-OFF DEVICES

When selecting a suitable design for the proposed aircraft landing gear is quite complicated because there is no real pattern trunk.

The proposed airplane, I chose as the best variant of a landing gear with the front landing gear. Its use is generally made up of current aircraft, as this concept a number of advantages, which are in tandem with the landing gear and tail wheel occur [6].

Another aspect that should be taken into account is that the chassis interfering as little as possible in handling the aircraft, which is the maneuverability of the aircraft. To this effect has been achieved, so the preferred option choice retractable landing gear. For detailed technical specifications I walk in the following chapters.

3.1 Load calculation of a landing gear

Implementation of the calculation shall be based on regulation CS-23, whose full name carries the title Certification Specifications for Category D airplanes NORMAL, TRAINING, acrobatic and commuter. This provision is base building code for that category of aircraft (max. takeoff weight of 2,000 kg). Naturally prescriptions requires use in calculating the gross weight of the aircraft and also perform the calculation for the extreme gravity, center of front and rear of the aircraft.

3.2 Landing gear loads with the wheel of the front chassis legs just above the ground

The following cases load a landing where the plane is nearly horizontal, while the front wheel chassis foot touching the runway surface. This implies that the total shock when landing is transmitted only to the main chassis, and whatever the CG of the aircraft. Again, the calculation we use K = 0.29 from regulation CS23 - Appendix C.

3.3 Landing gear loads at the high angle of attack

Landing with the big pitch and self-loading chassis is similar to the previous case. Thus, once again front undercarriage leg is loaded with a full load is transmitted only to the main chassis, regardless to center of gravity of the aircraft. It is also assumed pure vertical load.

3.4 Load the landing gear on a gear wheel

The condition for a wheel landing gear is assumed that the plane is horizontal and touches the ground only on one side of the main chassis. In this position, the reaction must be the same as the ground reaction obtained in a horizontal landing.

3.5 Side load of the landing gear

With a side load is encountered during landing with cross winds. The chassis is loaded with the same forces and the poor quality of the landing field. In addressing this burden, we will assume that the overall character of the landing will carry the main chassis, the vertical distribution is split evenly between both legs of the main chassis. Operating times the vertical load must answer the value of 1.33. Furthermore, operating multiple lateral inertia forces must be divided between the main landing gear wheels. These multiple lateral inertia forces as prescribed, with a value of 0.5 on one side of the main chassis acting towards the axis of the aircraft and the value of 0.33, on the other hand, acting on the axis of the aircraft.

3.6 Load the chassis during braking

Baselines for the calculation are again assumed for the aircraft in a horizontal position. Operating times the vertical load is 1.33, which is still necessary to consider that the power of acting in the horizontal direction has corresponding value of 0.8 times than the vertical force.

3.7 Draft of the front chassis legs

Pulling forward I will deal with the help of a hydraulic cylinder. Using this method will facilitate the emergency eject the front chassis legs. Pressing the absorber is 170 mm at maximum load. Front suspension is a telescopic structure, controlled located quite far from the center of gravity, so the burden will be borne by small and can easily be of simple design.

3.8 Strength calculation of the front chassis

The front undercarriage leg is stressed by the pressure and it does not create the complex forces and moments. Therefore, the individual measurements were estimated empirically, and the strength of several simulation in Creo Simulate its dimensions have been optimized so as to suit the strength but not too bulky. Strength model includes only the important parts for strength analysis as imposing a suspension of the strain. The steel material is chosen according to STN 16 532 for a fork, save. The stainless steel is very good for its properties and has very good hot ductility. It is used for highly stressed machine parts. Most trucks are used for aircraft wings, curtains, rod, and screw the piston has a predefined materials.

3.9 Descriptions of the front chassis

Fig. 1 Front landing gear (source: made by author)

Figure 2 gives the basic dimensions of the front chassis. Wheel size was chosen based on the wheels used on similar aircraft. This is a low-pressure tire. Wheel diameter is such as to allow sufficient volatility to use take-off landing surfaces (concrete, grass). Fork is made of steel STN 16 532. It connects to the wheel upright. The damper is chosen so that it can carry the load and had incurred the necessary rigidity. During the operation will be necessary to check its status will be stressed as well as lateral forces, which are unfavorable to him.

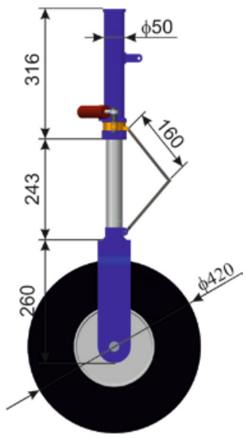

Fig. 2 Dimensions of the front landing gear(source: made by author)

Chassis are connected to pivot pins. Location of the pivots will be based on the height of the front of the chassis so as to maintain the body Horizontality the running gear that is static compression at the shock. The retracting landing gear pad is designed for anchoring retractable piston.

Control is designed with that occupied the least space and low weight. To control the use of double-acting hydraulic cylinder which is attached to the web of piston rod pivots lever mechanism is pivotally placed on web of. This mechanism is associated with the scissors, which transmit the rotary movement of the fork.

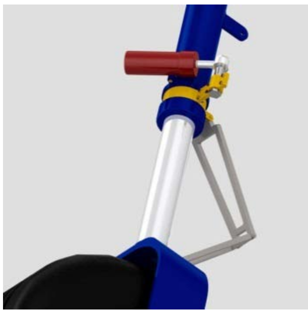

Fig. 3 steering mechanism(source: made by author)

Piston shooting while serving as damper side oscillations. Exact kinematics and retraction of the front chassis legs shooting is not the subject of my work and show mechanisms are only shown in principle and can serve in the next draft. Since this is a telescopic front body-foot store in the trunk (Fig. 5) will occupy a relatively large area. The length of 1100mm, width less than 200mm, height is variable, the maximum depth of 430 mm. Container size may be increased by way of dealing with the retractable mechanism.

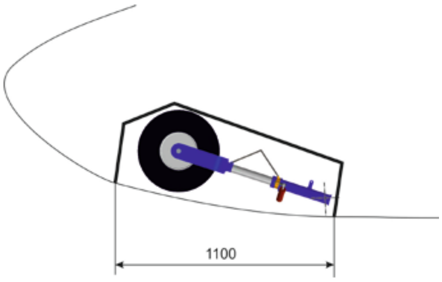

Fig. 4 placing of the front landing gear in the fuselage(source: made by author)

3.10 Draft of the main chassis

Disadvantage is that in order for the chassis with an adequate gauge must be located outside the body, most often solved by placing it into the side pods. We also rely on this assumption. This chassis is designed to have relatively short web which is reflected in low volume.

Unlike the front suspension, main chassis is just the center of gravity of the aircraft and will have to bear the substantial weight of the aircraft. In order to maintain its compact chassis is used lever concept which is much needed lift muffler.

3.11Strength calculation of the main chassis

The most stressed place on the main web of the chassis is horizontal, which is loaded in bending and torsion, the imposition of the shock, pivot pins deposit chassis and horizontal web of the move. It is given to the calculation of deposit suspension damper. The design of the chassis consists of seamless pipes made of steel STN 15110th Finished steel pins are the pins steel 11500th

The undercarriage leg has relatively the same tension of 600Mpa. Simplified model involves higher voltage in the sharp transition of the material. The full length of tubes formed a uniform tension. The main chassis strength is effectively designed.

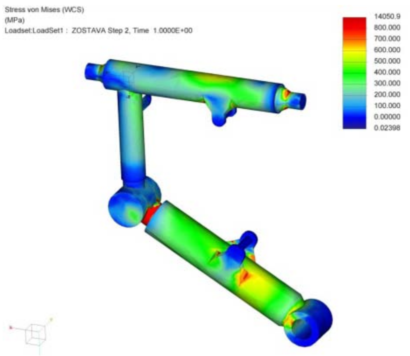

Fig. 5 Stress of the main landing gear(source: made by author)

3.12 Description of the chassis parts

The main chassis is a simple lever construction, a wheel towards to the axis of the aircraft. To save weight, was not designed as a fully covered. To construct an auxiliary nacelle is mounted with two bolts. Extension and retraction hydraulic cylinder is solved.

Fig. 6 main landing gear(source: made by author)

In Fig. 7 shows the basic dimensions of the front chassis. Wheel size was chosen based on the wheels of similar aircraft. This is a low-pressure tire. Wheel diameter is such as to allow sufficient volatility used to take off landing surfaces (concrete, grass).

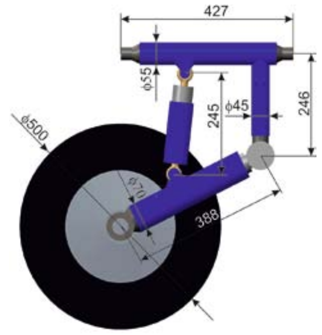

Fig. 7 Dimensions of the main landing gear(source: made by author)

The horizontal tube, where they are stored pivots are made of tubes with D = 55 mm and s = 5 mm. At the ends of the welded bolts that are placed in bed in the nacelle of the aircraft. These pins will rotate the undercarriage leg. The vertical shear webs are welded to the horizontal rotating bed. Damping provides oil-pneumatic damper pivotally attached to a horizontal bed and a horizontal web of. The web of the horizontal is mounted in the center to evenly distribute stress horizontal web. The upper part is fixed at a slight angle that best captures the character of the landing. The chassis must be accompanied by retraction kinematics, which also ensure the chassis pulled out of position. It will be supplemented by hydraulic hoses and cables leading to disc brakes.

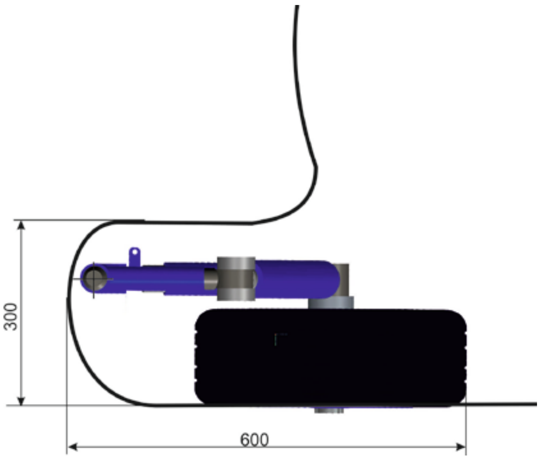

Fig. 8 retracted position of the main landing gear(source: made by author)

3.13 Draft Concept of retraction and ejection chassis

The retraction system solutions will be subject to other theses, therefore referred to as chapter outlines the issue. If the main landing gear is in practice almost exclusively on this category of aircraft used by pulling toward the axis or the axis of the aircraft. The reason for such a concept is related primarily to the change of gravity, because the movement of the chassis forward or backward, the main chassis inferred significant change since gravity is heavier than the front suspension .. Again, for the proposed aircraft, I choose the method of retraction axis of the aircraft, which would conceal the undercarriage covers all the main chassis with the result that would avoid unnecessary increase in aerodynamic drag in flight. Covers the main chassis and the front chassis legs are designed so as to open and close with the slider chassis. The link between the lever and the cover is designed mechanically.

4 FINAL CONCLUSIONS

The aim of this thesis was to develop a draft design of the front chassis legs and the main chassis. As part of fulfilling the objective was to develop a bonding calculation of the proposed construction. The requirements that were identified in the award, I compared the number of aircraft and found the option to meet the target. I decided the best suited option Vulcanair VR and 11 EM Orka. The more closely meet Vulcanair VR marked P.68R

The great part, I worked with a CAD program using CREO PARAMETRIC to me in no small measure to simplify the calculations. The work has brought a brief description of each part, the classification of types of chassis as I select the most appropriate approach. Based on the determined center of gravity of the aircraft performed a bonding calculation and suggested the appropriate deployment of landing gear components. The proposed airplane, I chose as the best variant of the type-wheel landing gear unit with the front landing gear. Its use is generally made up of current aircraft, as this concept a number of advantages, which are in tandem with the landing gear and tail wheel occur. For chassis to interfere as little handling of the aircraft and was maneuverable variant I chose retractable landing gear.

The main chassis strength is effectively designed.

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