DESIGN AND CALCULATION OF ENGINE MOUNTS AND ENGINE NACELLES FOR AIRPLANE WITH TAKE-OFF WEIGHT OF 2000 KG

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The thesis describes the design and calculation of an engine mount and engine nacelle for airplane with take-off weight of 2000 kg. The thesis describes the analysis of the current state of engine mounts, engine nacelles, fire dams, flexible storage engine airplanes with similar configuration and performance. The next part deals with own design and calculation of a engine mount and nacelle in the program PRO ENGINEER according to official regulations FAR/CS-23. Follows the calculation of the load acting on the engine mount mount, the material analysis and MKP analysis of eight model situations that can occur in flight. Thesis in the end solves the control to the loss of stability and strength of rods.

INTRODUCTION

From the very beginning was the construction of an engine mounts one of the main priorities of designers. Power units were heavy and relatively low power and strength of motor mounts was tested experimentally in flight. Engine nacelles were mostly designed as a simple metal covers are often made only two or three parts.

At present, the motor box dimensioned in various CAD programs, which will be specified load of the whole system. The great advantage of CAD design is that the designer is working on the computer. There is a 3D model of the engine and the need for sub-structure design.

My task is to propose the construction of the engine mount TP-100 engine and engine nacelles for the airplane to take-off weight 2000 kg, for five to six passengers.

The proposal I made in the CAD program PRO ENGINEER pursuant to applicable regulations FAR/CS-23. As I developed the first model engine dimensional sketch of the documentation.Followed by construction of the engine and nacelle bed. Whole system I have to charge, the subprogram for Mechanica forces calculated from the flight envelope, the gyroscopic forces and inertia forces and forces arising from the powerplant. As a final step, I inspected the rods and the buckling strength rods.

1. Analysis of the current state

In this chapter I will discuss successful aircraft types of similar configuration and performance, also will describe the basic engine of the buildings, their specific characteristics and purpose of the meeting.

1.1 Engine nacelles

Nacelles are shaped outer protective sheath of motor units and also their mountings fairings to aircraft structures. Mounting the motor drive unit with beds either directly to the construction of wings and connecting directly to the structure of the power unit and wing.

Construction: complete the aerodynamic shape of the aircraft at the drive train, engine and protect units from weather and mechanical damage. They provide air supply to the engine and creates interior space for its cooling, including cooling air outlet and the flue gas. In the event of a fire engine, it isolated from other aircraft design and deliver a sufficient concentration of extinguishing mixture. It also reduces the noise field around the power plant. They allow quick access to engine and aggregates as well as its ease of assembly and disassembly. They are addressed as quickly removable or flip panels with locks. These covers must be secured against the effects of wind on maintenance on the parking area. As proposed to airplane concept with the landing gear will be placed in the hull motor mount attached directly to the structure of the wings. This motor lodge designed pods allow the construction of complex shapes from simple non-bearing segments, which are the reasons most metal temperature. The segments can be designed as shaped plate with longitudinal stiffeners or tubular space frame composed of units of the longitudinal stiffeners and the perimeter dams on the upholstery sheets are attached either with screws or rivets.

1.2 Fire protection of an engine nacelles

It is known that the fuel could ignite if the mixture of fuel and air reaching explosive concentrations. It is very dangerous to store fuel in the tanks and non-ventilated areas. Fire in the engine nacelles can be avoided in two ways:

- Passive protection
- Active protection

Passive protection creates unfavorable conditions for the resulting fire, while active protection creates unfavorable conditions for the flare and the initial stage of burning fuel and oil. [11]

Structural measures engine nacelles for fire

• Adequate ventilation slots, which could create an explosive mixture

• Location of drainage holes and valves of accumulated fuel and oil

• Increase the tightness of fuel and oil pipelines

• saturation of the engine compartment with neutral gas

• Conducted connect all parts of the aircraft

Structural measures engine nacelles for the fire emergency landing

• Pumps, pipes and reservoirs must be attached to the main bearing of the aircraft

• Location of lever mechanisms under engine nacelles to crash off the mains and put in the fire system

• In the event of leakage or damage to exhaust the knees, not the hot exhaust gases flow through units at a fuel oil system

• Fuel and oil pipelines will not cross the intake manifold

They are structural components to prevent penetration of flammable mixtures in the engine compartment and a variety of heat sources that burn the mixture, to design wings and fuel tanks. This design protects the aircraft after a certain period of time necessary to extinguish any fire. In terms of fire protection is required that the airplane was designed so that in case of fire in an area, the fire can not spread to other areas either holes or damage to the fire wall. The same applies to flammable liquids and gases. [11]

The walls must be protected against corrosion and must withstand fire temperatures of 1100 degrees Celsius for at least 15 minutes. Resistance was demonstrated by testing. If not done, so you need to use metallic materials with a minimum prescribed thickness.

1.3 Engine mounts

Structural units are designed to be attached and transfer engine thrust to airplane design, which must meet the following basic assumptions:

• Ensure a minimum mass for the necessary strength and rigidity. It must be the requirement of certainty of shape which means that elements of the construction of the motor during operation bed not change its position.

• Adequate access to the motor unit and the aggregate during ground maintenance. Great attention is paid to the possibility of quick and easy disassembly of assemblies or accessories that have the greatest technical failure or rezurz shorter than the other units or the whole drive unit.

Quick and easy disassembly time powerplant. The two-channel and turbo air turbo engines is quite common that a number of engine bed hinges on the construction of the wings is greater than the number of suspensions for the drive unit motor lodge. The role of the designer must therefore be a reasonable effort to design for a substantial shortening of disassembly. [9]

1.4 Anti-vibration mounts

Drive units implying tensile strength by propeller showing considerable vibration. It is therefore important that the mounting points together with the drive unit connected through a silent block or shock absorbers. This ensures a flexible fit significantly reduce the frequency of pulses transmitted from the power plant construction in the wings.

In terms of physiological effects may be given orientation relationship for the permissible amplitude A (cm) and pulse frequency of γ (min-1):

$A\gamma 0, 5 << (4-5)$

The difference between the conventional piston and turboprop propulsion units is that the turbo power unit are substantially better mass balance. The vibration amplitude of them tend to be less than a tenth of the value of oscillations in piston powerplant. Turboprop aircraft with turbo engines run at high speed because of their high frequency pulses prevents resonance structure with wings. Notwithstanding these features, the flexible mounting also used for sealing turbo powertrain.

Impulses are transmitted from the drive unit in its storage in the wing operating in the plane perpendicular to the axis of the motor and the frequency is a multiple of engine speed nm. Impulses arising from the possible imbalance of the propeller operating in the plane of rotation of the propeller and the propeller axis.Stimuli acting on the propeller axis is caused by an imbalance or aerodynamic effects of wing propeller. Effect of the wings is the greater, the more the propeller axis is shifted above or below the wing chord. This is reflected mainly in the compression configuration. [11]

Engine bed is a rigid structure so that most of the oscillations can be in the range of operating speed. Flexible storage must achieve a significant reduction in natural frequency whole engine beds and wing structures to oscillations of the engine bed.

Stiffness of the engine beds are about the axis X, Y, Z different. Therefore it is necessary to appropriately adjust the stiffness of the vibration dampers. The vibration motor unit around the axis Y and Z occur, the effects of gyroscopic moments propeller, large oscillations, which are harmful to her. Shock oscillations must therefore have a greater rigidity to allow rotation of the motor axes.

The construction vibration dampers are used elastic rubber elements. The required stiffness in all three axes is achieved by thick rubber, or the modulus in tension and shear. Fluctuations in the direction of a small damper stiffness, shock, radial movements arising from a hard landing or emergency stops must be specified in their design. The maximum allowable motions of silencers are 5-6 mm. The rubber shock absorber in a very adversely affected by petrol and oil. Shock absorbers are therefore painted protective varnishes and concealed guards.

Parameters needed to determine the stiffness of the shock:

• Center mounting stiffness of the engine must be close to the center of gravity of the driving

• Allowable static shear load in the range 6 to 10 kg/cm2

• Allowable load in static pressure ranging from 60 to 80 kg/cm2

• Strength and elasticity of rubber is reduced at temperatures below -30 and above 60 degrees [11]

2. Power unit

TP 100 is a small compact engine turboprop simple design consists of two main modules: gas generator and free turbine reducer. The engine is equipped with autonomous oil system, electric starter, digital control unit, fuel systems, low voltage ignition source and the two drive to control speed propeller and propeller speed limiter. The gearbox can be mounted high-speed generator, which produces 3 kVA.

Characteristics of an engine TP-100: Built motor to be fixed by means of flying in all forces and loads resulting from flight and gust envelope

• fix the motor means for flying at all loads and forces generated by the propeller and the engine air or land operations

• Must ensure effective air supply to the engine intake system for flight conditions

• It must compensate for thermal expansion of length motor

• allows easy installation and maintenance of motor

• Minimize additional load on the engine

• Ensure ventilation of the engine compartment and engine cooling including electronics

The attachment points of the engine:

• Two sides of the reducer boxes labeled A1 and A2, to trap the reaction torque and propeller thrust

• One on the bottom or top of the compressor casing labeled A3, placed according to design the intake system

• The engine must be attached to the mounting points with rubber curtains [6]

3. FAR/CS-23

This regulation applies to airworthiness:

- Normal category airplanes, and aerobatic training in the configuration of nine seats or less outside seating pilots with an approved maximum take-off weight of 5,670 kg (12,500 lb) or less.

- Two-engine propeller-driven airplanes in service category for a collection of layout with nineteen or fewer seats, excluding pilots with an approved maximum take-off weight of 8,618 kg (19,000 lb) or less. [7]

Conditions for the construction of the engine beds: Any motor bed and its supporting structure must be designed for load following effects:

- Operating torque corresponding to take-off power and propeller speed acting simultaneously with 75% operating loads resulting from flight conditions and in accordance with EN 23333 (d);

- Operating torque corresponding to maximum continuous engine power

and propeller speed acting simultaneously with the operating loads resulting from flight conditions and in accordance with EN 23333 (d);

- For sealing turboprops in addition to those contained in the paragraph, the operating torque corresponding to take-off power and propeller speed, multiplied by a coefficient involving malfunction of the propeller control including quick feathering, acting simultaneously at multiple horizontal flight at 1g. If there is no rational calculation must be used coefficient of 1.6.

- Operating torque should be calculated by multiplying the mean torque coefficient:

a. 1.25 for turbo-building;

b. 1.33 for engines with five or more cylinders

c. 2.00 for engines with four cylinders,

d. 3.00 for engines with three cylinders

e. 4.00 for engines with two cylinders

Side-load engine beds:

Any motor bed and its supporting structure must be designed for operating multiple loads in the transverse direction, the lateral load bed of a motor, which shall be not less than:

- 1.33

- Third times the operating load for flight condition A.

May be assumed that the side load prescribed in sub paragraph (a) is independent of other flight conditions. [7]

4. Design of an engine mounts and engine nacelles

4.1 Design of an engine mounts

The proposal I made the engine mounts in Pro Engineer CAD program. I based the model of the drive unit TP-100, carried out by dimensional drawings provided in the technical documentation. It was originally designed for small helicopters and small planes with sporting power unit in the compression configuration. My task was to design a motor lodge, which would allow the use of traction motor configuration.

To attach the engine to the airframe structure I have chosen the lattice structures (Fig. 14), which consists of welded pipes of constant cross-section (Chapter 6). Rod system consists of two closed units interconnected as to be able to carry traffic loads. (source: own processing)

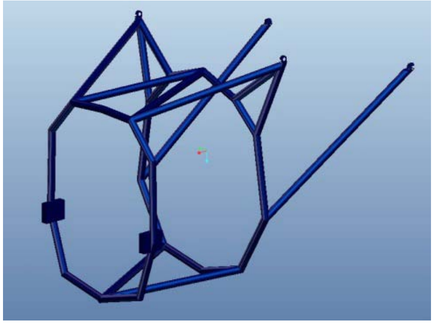

Fig. 1 Design of an engine mount

Units must be structurally designed as a partition, for sealing the engine. This is due to the mounting location of nodes on the drive unit housing reducer, front exhaust elbows. Motor unit would have to remove the exhaust bends, which greatly complicates the maintenance of the land (Fig. 15). Lattice structures by their design, and based on weight much better and easier if the attachment nodes were placed at the output deck housing the compressor or combustion chamber. (source: own processing)

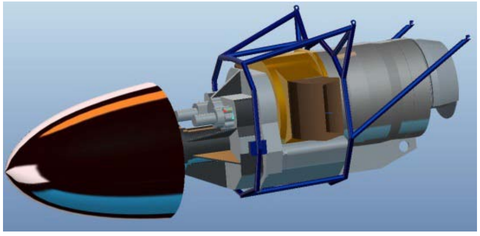

Fig. 2 Assembly of an engine mount and motor

Drive unit is fastened to the engine mount on flexible hinges that allow dampen vibrations resulting from the operation.

Motor lodge is to construct a wing attached to the four mounting points by flexible hinges. The front two nodes are attached to structures reinforced beams leading edge shape and no two are attached to the main spar (Fig. 2.)

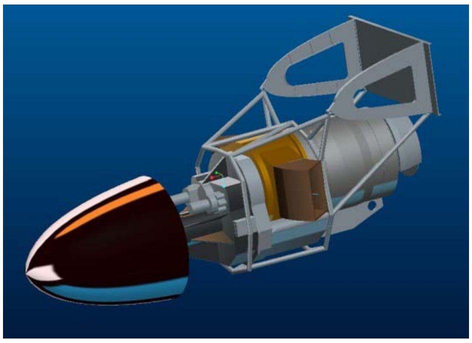

Fig. 3 Final assembly of engine mount, turboprop engine and construction of a wing

4.2 Design of engine nacelles

The panels are mounted engine nacelle fire on three dams (Fig. 17), whose structure is fixed to the structure of the wings. The dams and buildings motor I chose reasonable discretion, guaranteeing undistorted due to operational loads. Area fire dams is as small as possible to reduce frontal drag, and especially the whole weight of the motor development. I put great emphasis on smooth transitions, especially areas like paneláže to avoid creating an interference resistance. Paneláž is made of duralumin profiled sheets with a thickness of 0.2 mm. (source: own processing)

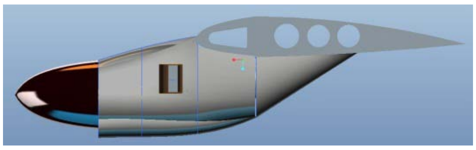

Fig. 4 **Engine nacelle**

External input system is guided longitudinally in the bottom of the engine nacelle (Figure 18) and passes smoothly to the engine inlet tract. Cross-section of the suction channel has been the subject of my thesis is therefore chosen according to the approximate cross-section similar designs used in similar engine mount. (source: own processing)

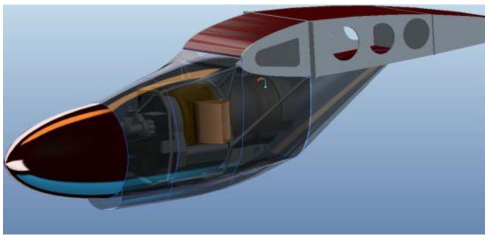

Fig. 5 **Final assembly**

5. Material analysis

The motor lodge I picked material with high strength, good weldability and is used for machine parts exposed. On the basis of technical documentation from similar types of storage engine, like the construction of the steel L-ROL.6 or steel 14331st Steel L-ROL.6 - Steel Mn-Si-Cr intended for cultivation of. Steel is a well-wrought by heat and stands a good workability. It is used in the manufacture of machine parts such as bolts, screws, nuts, shafts, riveted and welded to the structure. Very good weld, provided it is made from heating the material. [13]

The basis of the lattice structures are seamless tubes of constant cross section (Fig. 20) with an outside diameter D = 15 mm, an inner cross section d = 10 mm, wall thickness of 2.5, and different lengths, which are bonded together by welding and screws.

6. Conclusion

The aim of this thesis was to develop a draft of the engine mount and engine nacelles for airplanes with maximum take-off weight of 2000 kg, for five to six passengers. As the drive unit was chosen turbo engine turboprop aircraft TP-100. In the first part, I analyzed the current state of airplanes of similar configuration and flight performance, analysis of the basic conditions and purpose of all units of motor development. Selected chapters I have described as brief as possible and focusing only on turbo-jet engines, but also like to mention the most basic information on this issue. In the second part I analyze the parameters of the drive unit and propeller. I have described the basic engine design analysis of the weights of the aggregates and the actual engine, engine mounting nodes and basic dimensions of the engine. Propeller design I did not pay attention, as has been the subject of this work. I mentioned only basic information. In the third part I took and translated the chapter concerning the design of a motor under load conditions of lodgesFAR/CS-23 regulation. In the fourth chapter, followed by a complete draft of the engine mount and engine nacelles in the program PRO ENGINEER. The proposal is accompanied by many pictures with a basic description of the structural elements. When creating a computational model I have encountered several problems. As the power unit was not originally considered in configuring and securing traction nodes are placed on reducer housing from the engine exhaust elbow, there was a significant weigh bar systems. The structure is thus composed of two interconnected ring design elements to circumvent knees engine exhaust. The second ring element placed rods that are placed on the engine bed design with construction wing. The engine mount must be designed as a split that was not possible to fix the motor on the motor lodge. Another problem arises when modeling circular elements. As the CAD program would not accept the curve formed by which the load should be calculated in circular design elements, I had a proposal to transform into short pipes connected to well and faithfully reproducing the motor circuit. The calculation was carried out in order. In the fifth chapter I have dealt with the calculation of loads resulting from flight envelope, the gyroscopic loads and inertia forces and loads generated by the engine. Finally, I made out the flight and gust envelope.

In the sixth chapter was given a construction material for motor lodges with a description of the basic features of the data required for calculation and display of model cross-section tubes. In the seventh chapter, I conducted FEM analysis of eight core model situations that can arise in flight. The analysis shows that motor lodge is able to transfer all the load multiplied by the factor of safety of 1.5. Rods meet the fortification requirement. Finally, I conducted fortification control rods for the loss of stability and strength. All bars meet and are able to carry the load. In this thesis, I will not deal with the design flexibility of the engine of a motor lodge, bed and engine design on the wings. Also, engine nacelle design is only illustrative, because it was known through the imposition of aggregates on the engine and therefore it is necessary to propose the location of removable or flip covers aggregates for ground maintenance. The work was not designed or external input system engine. Cross-section of the input channel is approximately determined by engine nacelles powertrain airplanes listed in the first chapter. These structural problems should be addressed in future work.

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