DESIGN AND ANALYSIS OF ENGINE BEDS TURBOPROP ENGINE AI-450S-2 FOR SMALL AIRCRAFT EV-55

Peter Malatin – JozefJudičák – Karol Semrád

This thesisdeals with the designandanalysis of the enginebedsforselectedsmallairliner. In thework an analysis ofthe current situation ofthe engine beds structures ismade, andthere are alsodescribedthe fundamental conceptsandterms usedinthis issue.Furthermore,iscarried out the itself design process of construction of the motorbed for the turbopropengineAI-450S-2 forsmallaircraft carrierEV-55. Thereare analyzes of the airframemodifications in terms of building regulationsFAR-23. Subsequentlyisperformed the bonding calculationandmaterialanalysis of the designedconstruction.The workis supplemented bypicturesandtechnical descriptions of thedesignedconstructionas an annexes.The presentthesisconsists of six chaptersandelevenattachments.The main part ofthe document, two chapters, are thestructural designandcalculation of theconstruction of the motorbed.One of theattachmentsisathree-dimensionalmodelof the suggestedconstruction.

K e y w o r d s. Engine, enginebeds, FEA, illustrations and figures

INTRODUCTION

The engine of the aircraft as motor drive is not connected with the aircraft directly, but it is attached through an auxiliary structure, called motor thalamus. This fact must be taken into account and the motor bed must be designed by the aircraft designer. EVEKTOR Company Ltd as a manufacturer of aircraft in the Czech Republic, has commissioned the design of such a requirement, however for already existing aircraft engine beds. The difference in the draft for the existing aircraft and for new aircraft is in the fact that for the existing aircraft should be taken as the smallest airframe structure adjustment to not increase costs. Submitted thesis addresses the separation of the motor itself and its stress analysis.

1ANALYSIS OF THE CURRENT STATE

Because the reasons of production, design, service, and strength the aircraft power units are not installed directly into the airframe structure, but through a special fixing structures, called engine beds. [3]

One of the most important elements of the system are the beds of the motor drive, right behind the engine. Associated with a serpent aircraft powerplant. Their basic function is to ensure that the relative position of the engine with regard to the aircraft structure and transferred all burdens, drawn from the engine to the aircraft frame (the engine inertia forces and move gyroskopic moments). The bed must be simple, light, the motor must allow easy access to the power unit for traffic and at the same time its easy installation/dismantling in the revisions and corrections. Mute the vibrations of the engine and transmission must be maximum to prevent their aircraft to the aircraft frame. Silencers are located most commonly between the engine and the motor bed. [1, 3, 4, 5]

1.1 REQUIREMENTS FOR MOTOR BED

Motor bed of any structure must comply with the essential requirements:

1. *Minimum weight of sufficient strength and rigidity*. The requirement of a minimum weight while maintaining sufficient strength and rigidity is inherent to all backbone structures and aircraft structure in general and it looks at the giant building mechanics and strength of the aircraft thoroughly. As well generaly and an obvious requirement is counteracting the (geometric) certainty, i.e. maintaining the relative positions of members of the structure. For some types of structural design of motor is not consistently met this requirement beds. These types of structures are from the perspective of seizures of opposite direction load exceptional system or a system close to exception.
2. *Free access to the engine and its attachments*. Engine bed shall not impede the free and easy access to all parts of the engine and its accessories, requiring systematic control and regulation, such as the ignition system, the filler throat, reducer, filter pumps, slot, tap by

carburettor, and the like. In addition, the easy and rapid exchange must be identifiable as such accessories, which suffers the greatest failure rate or has less life time than the engine itself, such as plugs, sockets, magnetos, exhaust combustion chambers of engines and other.

3. *Quick and easy replacement of the power unit.* Quick and easy replacement of the power unit is required especially for combat aircraft. Experience has shown that when piston engines is the time required for the exchange of significantly shorter, if the engine is taken and with the motor bed. For Jet engines, and turboprop is in most cases, on the contrary, mainly for the reason that the number of hinges on the aircraft frame is higher than the number of beds to bunk engine hinges. In any case, must be sought by allowing easy and fast exchange of the engine constructor, as the combat aircraft to increase alertness. It is the reduction of the time required for transport aircraft to repair (replacement) of the engine.Contributes to, especially such a configuration in which the engine and at the same time with all the essential elements of the power unit and the engine bed scanning, i.e. the suction and exhaust pipes, motor covers, oil tanks, the tank with the coolant fluid, coolers, etc. Such a complete exchange of power unit can easily take place in particular with jet and turboprop engines where usually many of these parts are an intrinsic part of the engine.

4. *Suitable engine fairing.* Arrangement of motor proper aerodynamic separation must not impede the engine fairing, especially in the case where the motor unit is located outside the hull of an aircraft engine in the pod. For airplanes with engines in the hull is mostly influenced by the external dimensions of the beds of the arrangement of the contrary part of the trunk.

5. *Flexible clamping of the engine.*Engine beds, especially for units making considerable vibration (piston engines, the engines with the propeller), should contain a device the remedying of direct transfer of these vibrations to the airplane frame. Of these so-called vibrations silencers (absorbers) will be a more spoken in the unit "Flexible storage engine".

6. *The adjustment of the axis of the engine to the appropriate direction.*Engine bed should contain elements permitting in a range of settings of the axis of the engine to the position relative to the axis of the aircraft, and for the assembly and after the exchange of the engine, in exceptional cases and after finding serious flaws in test flights of aircraft.

7. *Prevent the transmission of thermal distortions of the power unit to the airplane frame.* Thermal deformation of the engines, especially engines with combustion turbines, reaching in the part where the burning occurs, significant values up (5-10) mm axial and radial direction as. Even more are the axial heat of exhaust pipe jet engines. With regard to the strengthening of the airframe structure and arrangement of the engine itself is unacceptable such a separation, which would prevent these distortions.

From these basic requirements to attach the power unit in the airframe follows the inadequacy, and often inability to direct implementation of power unit into the airframe structure, as it has already been mentioned above. For the use of the bed also says the fact that excludes (where, however, forms the bed of the attachment of the body in the space of a certain set of statically) the transmission to the engine block and the construction of the carrier's forces structure does not increase as its adverse stress. [3]

1.2 LOAD ON THE MOTOR

The engine bed, however, must be designed, in particular, with regard to motor on load, which in the operation of aircraft, and during the flight and on the ground, are formed. These load, indicated on the figure. 1, are in particular:

- the Mass forces, i.e. from the weight of the engine accessories including G_m on engine bed suspended (for example, propeller, various aggregates, the motor itself, or the engine guards, bed ...) and the respective inertia forces in accelerated flight cases, whether cases of landing. They operate in the gravity of these masses.
- Thrust power unit T_X – operates in the axis of the propeller or the axis engine. Deviation of the direction of the thrust of the engines, given by turboprop for an exhaust pipe in single engine aircraft with the engine in the front part of the hull, doesn´t have significant influence on stress separation of the motor and can be mostly ignored.

- The lateral inertia force F_Z from the engine and attached aggregates, resulting from curvilinear flights.
- The reaction of torque of the propeller or jet (except for propeller) engine, M_X.
- Gyroskopic moments M_Y, M_Z aircraft movements when revolving.
- The aerodynamic forces on the engine fairing, if these parts are attached directly to the engine or the engine bed. [3, 5]

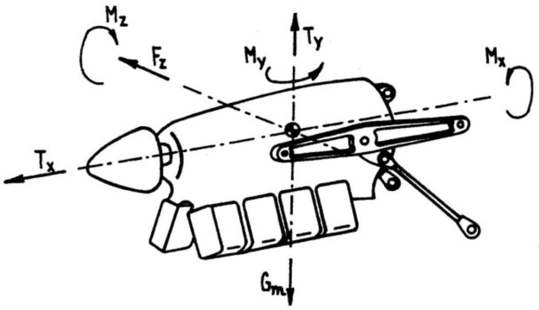

Fig.1 Loads on power system [5]

How to determine the size and direction of the forces and moments, is given by the relevant chapter's air strength rules. From simple consideration shows that the forces acting on the motor are particularly in the beds of dexterous aircraft with strong and heavy engines of significant values. It is also obvious that burdensome forces and moments may operate generally in all directions. Next to them the terms of the external shape of the power unit and the spatial location of hinges and the possibilities of a relevant part of the structure, therefore, resides the strength aspect which most influences the choice of the concept and the construction of the engine bed. [3]

1.3 TYPES OF ENGINE BEDS

Motor bed forms the supporting structure, designed according to a particular shape or beam and type of engine. Motor type power unit and place his bed is the intended attachment.
Basic types of beds:

- Beam (stanchion),
- rod (lattice),
- engine beds overhead and side pylons.

Beam beds – illustrated on figure 2 even with the quick connect curtain. They consist of two parallel or forward the radiating beams between which are inserted the engine. Girder with braces for example beam are enshrined into the diesel fuselage dam. The engine is attached in four points. [4, 1]

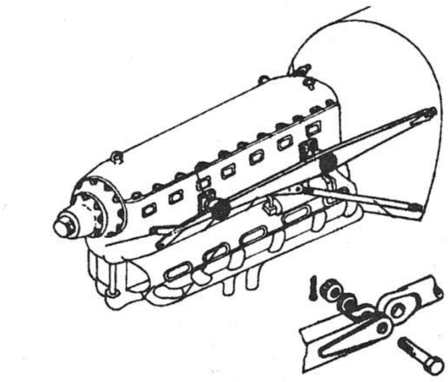

Fig. 2Beamenginebed [4]

Rodengine beds – also known as lattice, are used for storage of the piston engines (terraced houses, star) and turboprop engines. Rods with this type of separation is a minimum of six, eight, however, more often due to backup in case of fatigue failure. On the figure 3 for the piston engine(1) is the motor thalamus (2) with a vibration silencer (4) anchored in the fire wall (3). Rodpiston engine star bed consists of a circular frame, to which is attached an engine, and direct the construction of dams in the anchor rods for the fire. Rod engine bed is more complicated because of the length of the bed of turboprop engines. Often it is necessary two or even more gripped engine in hinge planes, as shown in the figure3 [4, 1]

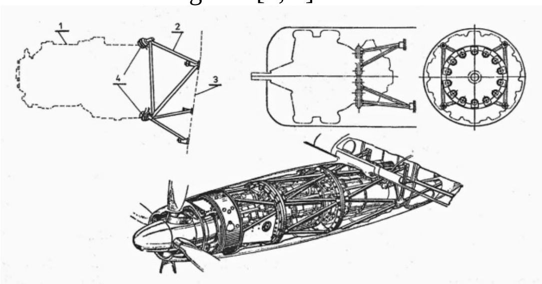

Fig.3 Rod engine bed line, star and turboprop engine [4]

Pylons – a large transport aircraft with multiple engines located either on the wing or are attached to the hull of the pylons under the tailsection(lateral symmetrical location of two engines, possibly the third in the vertical tail surface). Pylon motor bed consists of a special beam, attached to the bottom of the wing, which is hanging up a motor unit, as shown in the figure 4 to be dropped on the sides of the hull is used to eliminate the hanger drive units, which function is clearly apparent from the transmission of spur from the front of the holster on the engine thrust ensures transverse to the rear of the holster to hull mount. [4]

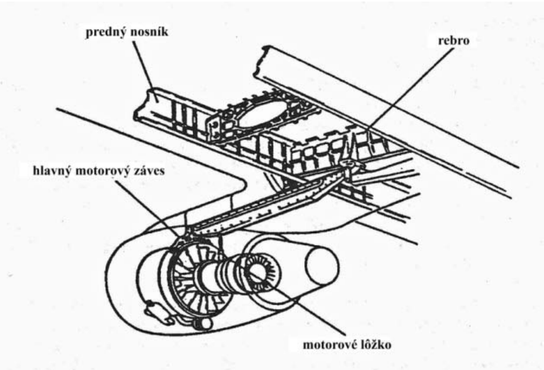

Fig.4 Pylon hanging of the power unit [4]

1.4 THE CURRENT STATUS OF THE CURRENTLY USED ENGINE BEDS ON THE REAL AIRCRAFTS

As beds have already so many types of drive units than in the past, it is also the use of the full range of engine beds limited. Large transport aircraft are powered by jet engines which are installed in the pylons under the wings.

The aircraft McDonnell Douglas DC8 and its engine CFM-56 usesfor hinging the engine in the podhinged on pylon under the wings.

Jet engines are stored in pylons under the wings affixed to the motor pods. On the picture below is shown empty engine pod.

Fig. 5 GE-CF6 aircraftenginepodfromBoeing 747 [7]

Turbo-prop engines, are used for smaller transport aircraft and sporadic even for small sports aircraft. As an example of a twin-engineturboprop aircraft can be used LET L-410 with engines GE-H80, which are mounted below the wing using engine beds of truss structure.

Less often the case use turboprop engine is single-engined arrangement. When is it on the wall of the engine used the simple design of the motor bed on the front of the hull separation is attached with the rod. These aircrafts are largely sports and recreational. An example of a simple rod construction of the engine bedis from the aircraft Zenair CH 701 STOL. These aircrafts are characterized by short take-off and landing distance, indicating also by the abbreviation "STOL" aircraft in the title. Each year in the United States the ability to land and take off at the shortest distance is the competitions of the pilots.

Piston engines are more common variantfor small sports aircraft as anpowerplant. These motors are attached to the front part of the hull of an aircraft by using a simple truss structure.

2 DESIGN OF ADJUSTMENTS ON THE STRUCTURE OF THE AIRCRAFT

To reengine is that when using a different engine variants are at least differences on aeroplanes. It is assumed that the bed will remain consistent with the previously used a variant of the curtains of the motor on the top of the front wings. It is also a prerequisite for the consideration of the use of the stop so far to the fire of the dam. Plane propeller will be identical from the present plane propeller, to comply with the regulations, and to have to scroll FAR-23 dam, which are situated just in the paved optic hull, propeller plane.

For these reasons, no adjustment to the construction of the wings are mentioned, nor the other structural parts of aircraft structure.

2.1 DESIGN OF THE ENGINE BED

The engine beds must be designed with regard to the requirements for the position of the engine and at the same time on the strength requirements of the structure, as defined in regulation FAR-23. As mentioned, no adjustment to the construction of the aircraft and it is therefore necessary to maintain the propeller plane of the original engine and its axis of rotation. These conditions determine the exact location of the engine under the wings. The construction is welded from steel tubes material 14 331 (steel L-ROL) according to STN 42 0074. Nasal tubes have a diameter of 35 mm and wall thickness of 2,5 mm. Auxiliary structures are 25 mm in diameter of tube, with a wall thickness of 2,5 mm tubes ensure the integrity of the construction of the engine.Given that the engine does not have to be considered as a solid body, so for auxiliary load transfer tubes. Bed is on the wing anchored in four hinged points, using the sidings and shoulder screws M10. The engine is attached to the bed in two main points and in two auxiliary points of fixing.

3D model of the construction of the motor is drawn up in the 3D environment using CAD software separation "Creo Elements/pro 5.0". The software is chosen because of the simple interface, and also acceptable because of possible stress analysis model in the implemented components of the software, the "Mechanica", using a method of final elements. The following figure is the construction of the engine bed model scheme.

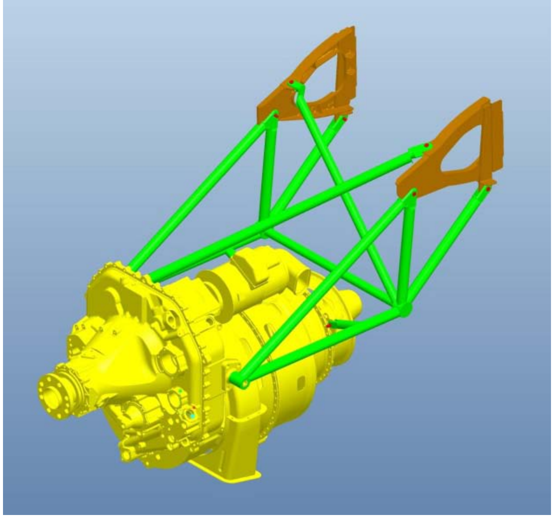

Fig. 6 3D model ofthedesignedconstructionoftheenginebed

3 THE STRENGTH CHECK OF THE DESIGNED ENGINE BED

Subsequently the strength check of the designed structure was carried out by the fact that it was first intended load engine bed according to the cases defined in regulation FAR-23. Also taken into account the weight of the load of the engine torque (torque reaction), thrust of the propeller, inertial forces and gyroskopic moments.After the findings of an analysis method of ultimate load of the motor bed FEA elements.

Since the work is bound by a confidentiality agreement, which concerns mainly the calculation results of the work, it is not possible to publish these results. The final result and evaluation of structure is found in the coclusion.

CONCLUSION

A summary of the theoretical knowledge has resulted to the assumption that the most appropriate option for the aircraft and the specified engine was the rod structureof the engine bed. Since the thesis was notabout a sealing of the engine for the new aircraft, but about the changing the engine to a pre-existing aircraft, was made no adjustments or changes of aircraft wing structure design.

The subsequent calculation of the flight envelope and load gust and from it based on the analysis of the cases with the load, he led the FEA. On the construction of the motor and the load applied to the beds of modeled computing software have already computed the results, which are neatly displayed in figures. As we can read from the pictures, the tensions and distortions resulting from the construction are not in any way critical, before moving in the lower levels. This means that the proposed structure and also the material used for the construction of the structure are suitable for use in operation.

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[7] http://www.airteamimages.com/pics/20/20971_800.jpg

AUTHOR ADRESSES

Ing. Peter Malatin, TUKE LF, peter.malatin@tuke.sk

Ing. Jozef Judičák, PhD., TUKE LF, jozef.judicak@tuke.sk

Ing. Karol Semrád, PhD., TUKE LF, karol.semrad@tuke.sk

Reviewer: Ing. Milan Seman