DESIGN AND ANALYSIS OF ENGINE MOUNT FOR THE USE OF MODERN-DESIGN ENGINE IN SMALL SPORT PLANE ZLIN 26 SERIES

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This article describes methods of engine mount design for the use of present modern design engines in small sport plane Zlin 26 Series. The article describes methods of defining entry conditions for engine mount design, methods of choosing appropriate engines for replacement. In the next part of article there are descrimount methods of geometrical dimensions and force loads calculation. Calculated force loads are necessary for construction strength analyses.

Keywords: Engine mount, Zlin 26 Series, Rotax 914, UL Power 350, Rotec R2800

1 INTRODUCTION

Czechoslovak aviation industry experienced a great development in the 50's of the last century. The result of this technology development are several successful aircraft designs, which are still used to this day. One such aircraft is Zlin 26 Series. Since the flight of the first prototype this plane has undergone many design modifications and various versions were produced over 30 years.

With the amount of modification was also associated development of various power units. Nowadays, however, starting to show a lack of power units that were originally intended for this type of aircraft. At the same time, however, the possibility arises of proposed new buildings to existing engines. In order for this to be realized it is necessary to address the issue of the draft motor mounts for these power units. Development should lead to the ability to sustain flight favorites Zlin Board 26.

Draft engine mount brings a number of problems with which the designer must deal with. To be successful such a proposal viable, therefore it is necessary to have sufficient knowledge of the field of aeronautical engineering designs.

2 PRESENT SITUATION - ANALYSIS

As mentioned in the introduction of the aircraft Zlin series of 26 passed during its development board modifications. With modification was joined by the fact that the power has been so far, a wide range of engines. This is a different powerplant various performance parameters and design concepts. Overview previously installed engines with the power parameters in the following list:

- **Walter Minor 4-III** [105 HP (77 kW)]
- **Walter Minor 6-III** [160 HP (118 kW)]
- **Avia M332** [140 HP (103 kW)]
- **Avia M137A** [180HP (132 kW)]
- **Avia M337AK** [210 HP (154 kW)]
- **Lycoming AEIO-540** [260 HP (190 kW)]

Performance powerplant has a significant impact on flight performance of the aircraft. A review of the previously installed engines it is obvious that the output is in the range of 105-260 hp. The range ensures the complexity of using the version of the aircraft Zlin Board 26 for various types of operations. While the weakest version with 105 horsepower output is used primarily only for tourist flights, versions with an output of 160 horsepower is also used to practice stunts or for towing gliders.

Also, it is a power unit of various design solutions and thus it is possible to have to deal with different choice of design layout of the engine mount. While most engines are inline with the arrangement of cylinders in a row, the Lycoming engine cylinders stored at each other and it is a so-called boxer. When arranging a row of cylinders is preferable to use a motorized mount girder type. In the arrangement of cylinders at each other all the engine mounts on the back wall and it is preferable to use a motorized mount frame structures.

3 ENGINE MOUNT DESIGN AND PRESENT STRUCTURE CHANGES OF AIRCRAFT FUSELAGE FOR USE OF NEW DEVELOPED ENGINES

Before the draft engine mount is necessary to determine the entry requirements as the powerplant to be built and to modify the current design of the airframe as well as the mount itself. For this particular design input requirements are:

1. When designing the engine mounts,ensure the smallest airframe structural modifications Zlin Board 26 so as to permit the installation of the airframe with the original four nodes of type fork assembly - Eye on fire dam without their further treatment.
2. Power unit used must answer at least the weakest performance-installed version thus far Walter Minor 4-III with an output 105 hp at 2500 rpm.
3. Engine mount shall be designed so that it can be constructed from readily available materials for aircraft structures. Used are hollow rods of

circular cross-section of chrome molybdenum alloy steel 25CrMo4.

4. Position of the engine must be set so that the center of gravity range has been maintained as specified in the type certificate of the aircraft-126th Front limit position is that the propeller disk newly built engine will be located at a maximum distance as it was in the engine Walter Minor 4-III.
5. Axis of rotation newly built engine must be the location for the motor Walter Minor 4-III to cause the slightest change blowing control surface and the fewest changes in controlling the aircraft.
6. Strength calculation engine load mount must be implemented to maximize the positive and negative times the allowable load for aircraft Zlin Board 26 The highest values of multiples load a version of Z-526F and +6 g and-3g.

3.1 Choosed engines and their description

With respect to the requirement of the minimum power 105 horses have been selected for installation 3 engines of modern design from three different manufacturers. Engines are also chosen with regard to their conceptual design. Engines are preferred by more airframe Zlin Board 26 were installed, therefore, included two four-cylinder engines with cylinder configuration at each other and one radial engine.

Specifically, they were selected:

- **Rotax 914** [115 HP (85 kW)]
- **UL Power 350** [118 HP (87 kW)]
- **Rotec R2800** [110 HP (81 kW)]

3.1.1 Rotax 914

Rotax 914 manufactured by Rotax Aircraft Engines is a four-cylinder, four-stroke engine with cylinders stored against each other. Cylinder heads are water-cooled, air ram cylinders themselves. The engine is equipped with turbo turbo blower, two carburetors with constant pressure in the diffuser, with a dry sump lubrication, mechanical diaphragm fuel pump, ignition and dual circuit electric starter. Propeller drive is provided via a gearbox with ratio i = 2.43.

Figure 1- Rotax 914

3.1.2 UL Power 350

Engine UL 350 manufactured by UL Power Aero Engines is a four-cylinder, four-stroke engine with cylinders stored against each other. The engine is air-cooled, equipped with electronic fuel injection, ignition and dual circuit electric starter. Propeller drive is secured directly to the motor shaft without reducer.

Figure 2 - UL Power 350

3.1.2 Rotec 2800

Rotec R2800 Engine manufactured by Rotec Aerosport is a radial, four-stroke 7 cylinder engine. It engine is air-cooled, equipped with a carburator, dual circuit ignition and electric starter. Propeller drive is secured directly without reducer.

Figure 3 - Rotec R2800

3.1 Determination of engine mount dimensions

Draft engine mounts and identify the location of the newly installed engine will be implemented so that was maintained in the range of center of gravity specified by the type certificate of the aircraft-126th In order to be preserved must be satisfied torque sentence where klonivé moments newly installed engine and propeller to the median value of the center of gravity of the aircraft shall be equal to the sum of the moments klonivých for sealing the original engine Walter Minor 4-III and wooden propeller. It is also in determining the dimensions taken into account that the maximum distance drive propeller of a new building by fire walls airframe Zlin board 26 may be equal to the maximum distance as that of the propeller drive motor Walter Minor 4-III.

Rolling moment of power unit to the middle value of MCG can be determined from the equations:

$$M_{CG} = M_M + M_V$$

$$M_M = G_M * x_M \qquad M_V = G_V + x_V$$

$$G_M = m_M * g \qquad G_V = m_V * g$$

where:
M_M – pitching moment of the engine to the middle value of CG
M_V – pitching moment of the propeller to the middle value of CG
G_M – engine weight
G_V – propeller weight
x_M – distance between CG of the engine and the middle value of airplane CG
x_V – distance between CG of the propeller and the middle value of airplane CG
g – acceleration due to gravity (g = 9,81 m/s^2)

CG Range specified in the type certificate Zlin board 26 is given in the range of 23% to 26.5% MAC (mean aerodynamic chord). It can determine the location of the mean center of gravity, which will be subject to further calculations.

$$x_{CG} = 1000 \text{ mm}$$

x_{CG} – distance between the middle value of airplane CG and airplane firewall

Pitching torque motor Walter Minor 4-III and wooden propeller with a diameter of 2000 mm was determined using the above calculations for:

$$M_{CG(WM)} = 1816125{,}3 \text{ N.mm}$$

Maximum distance drive propeller from the mean center of gravity is in the drawings building engine Walter Minor 4-III shall be:

$$x_{Vmax} = 2215 \text{ mm}$$

The above mentioned dimensions for a better idea graphic are shown in Figure 4.

3.2 Determination of engine mount force loads

Before the strength check engine mount is necessary to calculate all the loads acting on the structure of the motor mount.

3.2.1 Static load due to engine and propeler weight

Mount should be checked even under static loading by gravity engine and propeller are not active when no other forces.

- Calculation of the static gravity load from the engine and propeller

$$F_G = m.g$$

where:
F_G – force load due to engine and propeler weight
m – engine and propeler weight
g – acceleration due to gravity (g = 9,81 m/s^2)

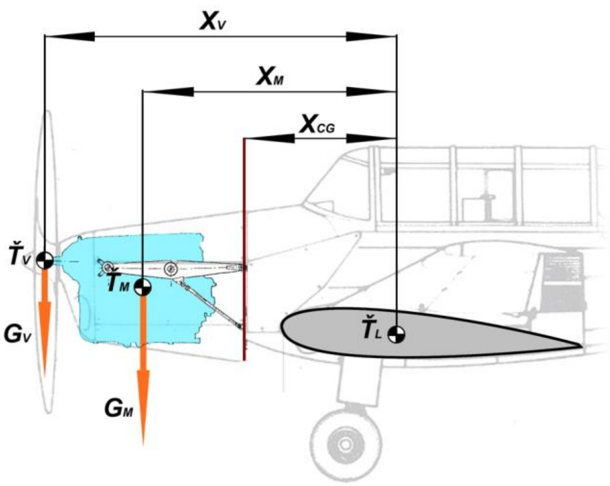

Figure 4 – CG dimensions

3.2.2 Mount load motor inertia force

- Calculation of load engine mount with considering the maximum positive load

$$F_K = m.g.n_{K\max}$$

- Calculation of load engine mount with considering the maximum negative load

$$F_Z = m.g.n_{Z\max}$$

- Calculation of lateral load engine mount with consideration of the side times the set building regulations FAR-23 (FAR 23363)

$$F_B = m.g.n_B$$

kde:
F_K – maximum load with considering the maximum positive load
F_Z – maximum load with considering the maximum negative load
F_K – maximum lateral load with considering multiple side load
m – mass of the engine and propeller
g – acceleration due to gravity (g = 9,81 m/s^2)
n_{Kmax} – maximum positive load
n_{Zmax} – maximum negative load
n_B – side load due to FAR-23

3.2.3 Engine mount load due to engine torque

- Engine torque calculation

$$M_K = \frac{P}{\varpi} = \frac{P}{2.\Pi.n}$$

- Calculation recalculated torque according to building FAR-23 for the construction of the power unit

$$M_{Kp} = k.M_K$$

kde:
M_K – engine torque moment
M_{Kp} – recalculated engine torque moment due to FAR-23
P– maximum engine power
ω – angular velocity of rotation
n – engine RPM with full power apllied
k – coefficient established regulations under FAR-23 engine concept

3.2.4 Mount load motor gyroscopic moments

According to building FAR-23, the construction of the motor to the load mount sized gyroscopic moments generated by power unit while turning angular velocity ± 2.5 rad / tilting speed is ± 1 rad / s. It is assumed that both of these moments acting simultaneously when a load of maximum sustained tension power unit at 2.5 times the load.

- Mass moment of inertia of the propeller axis of rotation - is used to calculate the theoretical formula for calculating the inertia rod with a length L and a mass rotating about an axis, which is located in the middle of bars, as the case propeller is closest to this arrangement.

$$J = \frac{1}{12}.m_V.L^2$$

- Calculation of the gyroscopic moment of the angular velocity changeover ω_Z = 1 rad / s

$$M_Y = J.\omega_X.\omega_Z = J.2.\Pi.n.\omega_Z$$

- Calculation of the gyroscopic torque for turning angular velocity ω_Y = 2.5 rad / s

$$M_Z = J.\omega_X.\omega_Y = J.2.\Pi.n.\omega_Y$$

- Calculation of the inertia forces at times n_{ZOTR} = 2.5

$$F_{ZOTR} = m.g.n_{ZOTR}$$

kde:
J – moment of inertia of the propeller axis of rotation
m_V – propeler mass
L – propeler diameter
M_Y – gyroscopic torque to angular velocity changeover ω_Z= 1 rad/s
M_Z – gyroscopic torque for turning angular velocity ω_Y= 2,5 rad/s
ω_X – angular velocity of rotation of the propeller
ω_Z – angular velocity of changeover
ω_Y – angular velocity of changeover
n – propeler RPM
m – engine and propeler mass
n_{ZOTR} – times the inertia forces specified building regulations FAR-23

4 STRENGTH CHECK AND 3D VIZUALISATION OF ENGINE MOUNT DESIGN USING COMPUTER SOFTWARE

In the design of the application software PTC ProEngineer. This software was used to create 3D models of motor mounts. 3D model was also needed for further use in the software of the PTC ProEngineer Mechanica, which served to implement strength calculations. Input parameters load and motor size mounts were calculated by the procedure descrimount in the previous section of this article.

4.1 Engine mount for Rotax 914 engine

Motor mount for a Rotax 914 is designed as a lattice structures of chromium molybdenum tube diameter of 19 mm with a wall thickness of 1 mm. The motor is attached to the mount with mounting frame supplied by the engine manufacturer.

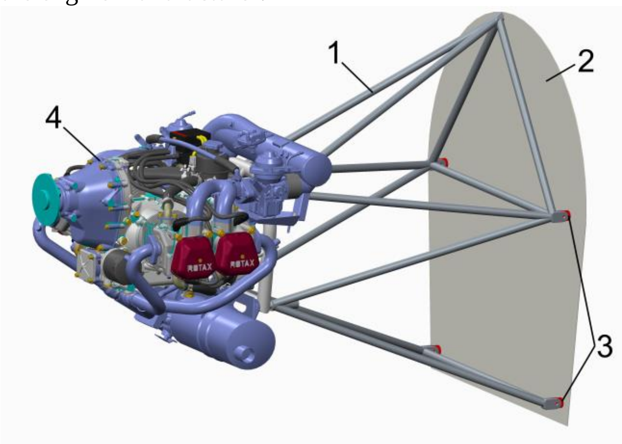

Figure 5 - 3D Model of engine mount for Rotax 914

1-engine mount, 2- firewall, 3- fuselage construction attaching points, 4- engine

Strength calculations has been shown that the choice of material and structure complies with the loads based on the input parameters of the proposal.

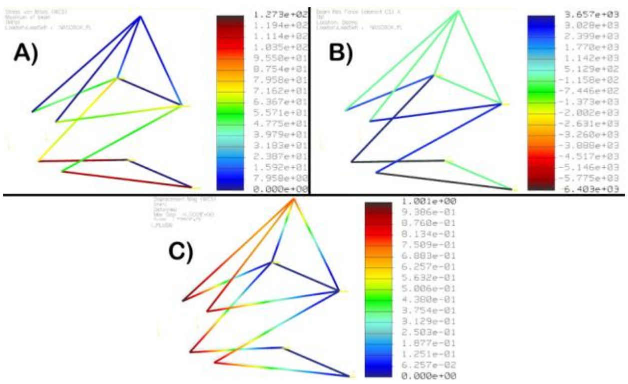

Figure 6 - Strength calculation results for Rotax 914 engine mount

4.2 Engine mount for UL POWER 350 engine

Engine mount for UL Power 350 is as in the previous case designed as lattice structures of chromium molybdenum tube diameter of 19 mm with a wall thickness of 1 mm. Motor mount is in place attach the engine modified to answer the design of the proposed manufacturer that supplies the engine and its flexible storage.

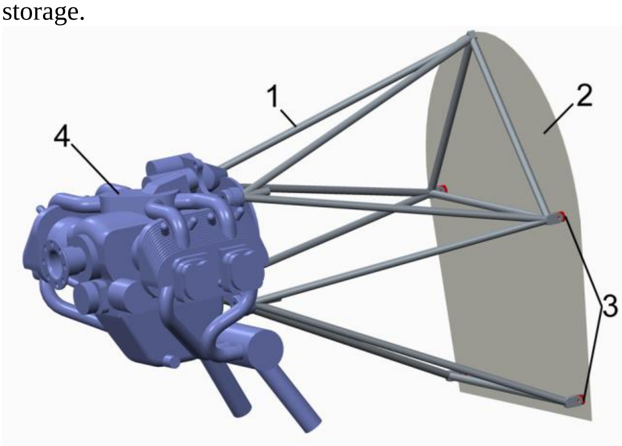

Figure 7 - 3D Model of engine mount for UL Power 350

1-engine mount, 2- firewall, 3- fuselage construction attaching points, 4- engine

Strength calculations has been shown that the choice of material and structure complies with the loads based on the input parameters of the proposal.

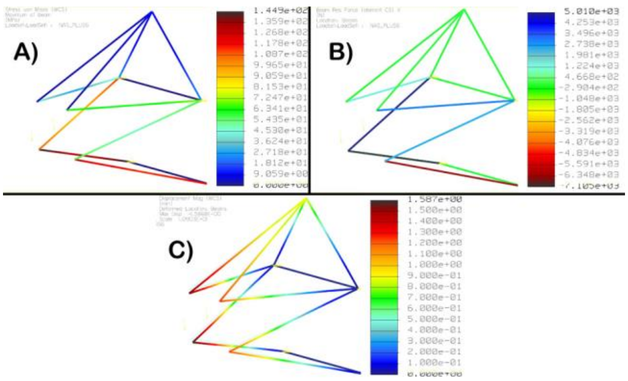

Figure 8 - Strength calculation results for UL Power 350 engine mount

4.2 Engine mount for Rotec R2800 engine

Engine mount for Rotec R2800 engine is just like in the previous two cases, designed as lattice structures of chromium molybdenum tube diameter of 19 mm with a wall thickness of 1 mm. Engine mount is in place attach the engine modified to answer the design of the proposed manufacturer that supplies the engine and its flexible storage.

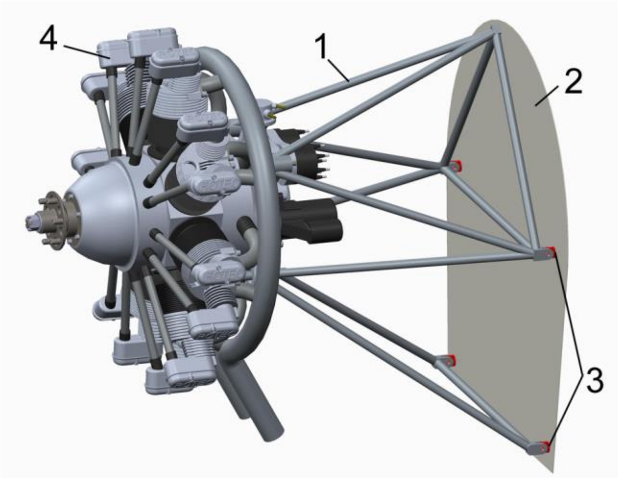

Figure 9 - 3D Model of engine mount for Rotec R2800

1-engine mount, 2- firewall, 3- fuselage construction attaching points, 4- engine

Strength calculations has been shown that the choice of material and structure complies with the loads based on the input parameters of the proposal.

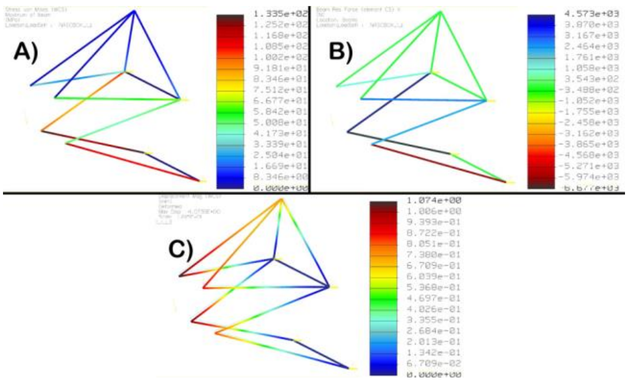

Figure 10 Strength calculation results for Rotec R2800 engine mount

5 CONCLUSION

The proposal of an engine mount brings up a number of requirements that must be met. Of the known information it can be inferred that the implementation of replacing of aircraft Zlin board 26 is not impossible, and using appropriate computational methods can be implemented such proposal for any selected motor with appropriate performance parameters. Specific proposals can be assessed as fit as strength test using computer software PTC ProE Mechanica showed that in all three cases, motor mounts meet the strength requirements of FAR set-23rd Solving the problem with the certification of aircraft modifications Zlin board 26 could lead to the application of the proposals in practical terms, and not just a theoretical as in this thesis. Development of the modern power unit into airframe mentioned aircraft could extend their operability for a further period which would certainly welcome the pilots but also fans of aviation from the general public that this type of aircraft grown very fond of. Selected parts are used to demonstrate the diversity of newly developed existing engines. The same procedure as described in the paper would enable devising a motor mount for any adequate motor parameters and thereby supplementing the already quite successful developmental series aircraft Zlin Board 26 One day we may meet a certified design of buildings or a diesel engine turboprop.

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