DESIGN AND ANALYSIS OF LOADING BRACKET FOR LANDING GEAR STRENGTH TEST

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Abstract - The main aim of the project is to design a loading bracket used for landing gear strength test. The loading bracket has to be designed in such a way that it should be rigid enough to sustain the heavy loads encountered during the landing gear strength test. The project covers the design and analysis of the loading bracket which involves the material selection, theoretical calculation of the loading bracket under various loading conditions and also comparison of theoretical results with computational results obtained using ANSYS 15.0 software.

Key Words: Landing Gear System, Loading Bracket, Vertical, Drag and Side loads, CATIA and ANSYS 15.0 software

1. INTRODUCTION

In aerospace industry, mainly working on the principle of Bernoulli’s theorem and Newton law’s of motion. Testing occurs in 3 stages, wind tunnel testing, ground testing and flight testing. In an aircraft, there are 4 parts namely Fuselage, wing, empennage and landing gear system. Forces acting on Aircraft are Thrust, Drag, Lift and Gravity. Control surfaces are change the attitude of Aircraft during flying. The main control surfaces are Ailerons (rolling motion), Elevator (pitching motion) and Rudder (yawing motion).

Figure 1.1 Landing Gear System

1.1 Landing Gear System

The landing gear system is placed in bottom surface of Aircraft. It carries the weight of an aircraft during landing and taxing conditions. It is one of the complicated part in an Aircraft. There are 3 types of landing gear apply to the surfaces are water, earthed and snow or ice (skis type).

During landing impact load absorbed by shock absorber (vertical load), when tire touches the ground drag load generated and side load due to the aircraft body. Types of landing gear are fixed and retractable landing gear. Classifications also based on wheels like single, tandem, triple and twin etc.

2. STRENGTH TEST

2.1 Test Specimen

Complete landing gear assembly was installed at the bottom of the drop test rig carriage. The wheel is replaced by loading bracket and shock absorber also replaced by dummy link.

2.2 Tests

The following tests are carried out:
- Vertical and drag load cases
- Spinup case
- Spring back case
- Vertical and side load cases
- Inboard acting case
- Outboard acting case

In 3 types of load generated namely vertical, drag and side load during landing and takeoff conditions on the tire.
2.3 Problem Identification
The following options also coming in mind
1. Circular profile similar to wheel
2. Fully machined block simulating the wheel
3. Plate with hub welded
Comparing the advantages and disadvantages, 3rd is best. The following advantages are reduce material consumption and machining cost, material handling is easy and machining operations are less.

3 GEOMETRY OF LOADING BRACKET
3.1 Material Selection
Carbon molybdenum (CM) steel is used for the bracket.

<table>
<thead>
<tr>
<th>Table – 3.1 Properties of CM steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
</tr>
<tr>
<td>Yield strength</td>
</tr>
<tr>
<td>Youngs Modulus</td>
</tr>
<tr>
<td>Ultimate strength</td>
</tr>
</tbody>
</table>

3.2 Design of Vertical Loading

Vertical load = 8900 Kg
Yield strength of material σ = 45 Kg/mm²
Plate thickness = 10 mm
Stress (σ) = Force / (ED × Thickness)
45 = 8900 / (ED × 10)
Eccentric distance (ED) = 20 mm
Factor of safety is 2
Eccentric distance (ED) = 40 mm

To find the Eccentric distance of drag and side load as same as vertical loading bracket procedure.
Eccentric distance (ED) of drag load = 24 mm
Eccentric distance (ED) of side load = 14 mm

4 ANSYS SOLUTION
4.1 For Vertical Loading

Figure - 4.1 Directional deformation of vertical loading

4.2 For Drag Loading

Eccentric distance (ED) of drag load = 24 mm
Eccentric distance (ED) of side load = 14 mm

Figure - 4.2 Equivalent (Von-Mises) stress of vertical load

4.2 For Drag Loading

Figure - 4.3 Directional deformation of drag load

<table>
<thead>
<tr>
<th>Loads</th>
<th>Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>8900 Kg</td>
</tr>
<tr>
<td>Drag</td>
<td>5320 Kg</td>
</tr>
<tr>
<td>Side</td>
<td>3010 Kg</td>
</tr>
</tbody>
</table>
5 THEORETICAL CALCULATIONS

5.1 For Vertical Loading

\[ \sigma_x = \frac{\text{Force}}{(ED \times t)} \quad \tau_{xy} = \frac{\text{Force}}{(\text{Area})} \]

\[ \begin{align*}
\sigma_x &= 87309 / (40 \times 10) \\
&= 218.27 \text{ MPa} \\
\tau_{xy} &= 87309 / (350 \times 10) \\
&= 2.5 \text{ MPa} \\
\sigma_y &= 0 \text{ MPa} \\
\end{align*} \]

Principle stress is

\[ \sigma_1 = 219.97 \text{ MPa} \quad \text{and} \quad \sigma_2 = -1.71 \text{ MPa} \]

Von-Mises stress equation is

\[ \sigma_{\text{von}} = \frac{1}{2} \left( (\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \right)^{1/2} \]

\[ \sigma_{\text{von}} = 220.83 \text{ MPa} \]

5.1 For Drag Loading

For 2 holes

\[ \begin{align*}
\sigma_x &= \frac{\text{Force}}{(ED \times t)} \quad \tau_{xy} = \frac{\text{Force}}{(\text{Area})} \\
&= 26094.6 / (24 \times 10) \\
&= 26094.6 / (350 \times 10) \\
&= 108.73 \text{ MPa} \\
\tau_{xy} &= 7.456 \text{ MPa} \\
\sigma_y &= 0 \text{ MPa} \\
\end{align*} \]

Principle stress is

\[ \sigma_1 = 109.23 \text{ MPa} \quad \text{and} \quad \sigma_2 = -0.51 \text{ MPa} \]

Von-Mises stress equation is

\[ \sigma_{\text{von}} = 109.5 \text{ MPa} \]

5.1 For Side Loading

For 2 holes

\[ \begin{align*}
\sigma_x &= \frac{\text{Force}}{(ED \times t)} \quad \tau_{xy} = \frac{\text{Force}}{(\text{Area})} \\
&= 14764.05 / (14 \times 10) \\
&= 87309 / (450 \times 10) \\
&= 105.46 \text{ MPa} \\
\tau_{xy} &= 21.1 \text{ MPa} \\
\sigma_y &= 0 \text{ MPa} \\
\end{align*} \]

Principle stress is

\[ \sigma_1 = 109.53 \text{ MPa} \quad \text{and} \quad \sigma_2 = -4.07 \text{ MPa} \]

Von-Mises stress equation is

\[ \sigma_{\text{von}} = 111.62 \text{ MPa} \]

Table 5.1 Comparison of FEM and theoretical values

<table>
<thead>
<tr>
<th>LOADS</th>
<th>FEM VALUES</th>
<th>THEORETICAL VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>197.2 M Pa</td>
<td>218.27 M Pa</td>
</tr>
<tr>
<td>Drag</td>
<td>145.65 M Pa</td>
<td>108.73 M Pa</td>
</tr>
<tr>
<td>Side</td>
<td>212.74 M Pa</td>
<td>111.62 M Pa</td>
</tr>
</tbody>
</table>

CONCLUSION

The results from FEM and theoretical values are minimal and within acceptable limits. From the above analysis concluded that the loading bracket is used for strength testing of landing gear assembly is safe.

REFERENCES

[4] CATIA Software file