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Design and Analysis of Loading Bracket for Landing Gear of an Aircraft

[1]R Rajkamal, [1]Naveen kumar N, [1]P Hemant kumar, [1]Nikhil R [2]Srinivas S
[1]Student, School of Mechanical Engineering, REVA University, Bangalore560064
[2]Assistant Professor, School of Mechanical Engineering, REVA University, Bangalore-560064

Abstract— The design and analysis of an aircraft component plays a key role during design of aircraft. 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 test. For stress analysis purpose, many software has been developed to calculate the ability and strength of the material to withstand loads and forces. The method approach is with the help of CATIA (to design) and ANSYS (to analyze) software. Hence during analysis, strength test is conducted and based on results of the landing bracket for landing gear, design is validated.

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1. Introduction

The aircraft industry involves in the designing, manufacturing, testing, selling and maintaining of the aircrafts and its part. This industry mainly works on the principle of Newton laws of motion and Bernoulli's theorem. Testing of aircraft occurs in 3 stages, wind tunnel testing, ground testing and flight testing. Four forces are acting in flight namely thrust, drag, lift and weight as shown in figure 1.

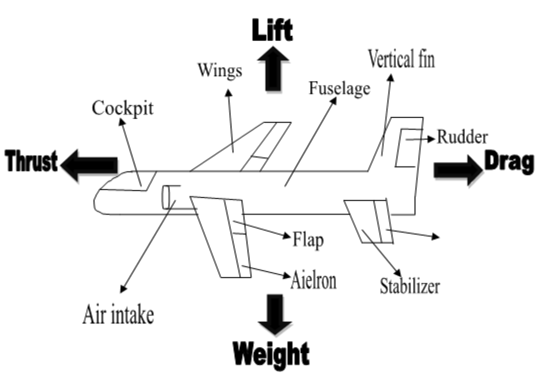

Figure 1.1: Forces of An Aircraft

1.1 Landing Gear

Landing gear is one of the complicated and critical part in an Aircraft. Landing gear is the undercarriage of an aircraft used for takeoff or landing. It supports the aircraft when it is not flying, allowing the aircraft to takeoff, land and taxi without any damage to its structure while providing comfort to passengers. The landing gear design takes into account of various requirements of strength, stability, stiffness, ground clearance, control and damping under all possible ground attitudes of the aircraft.

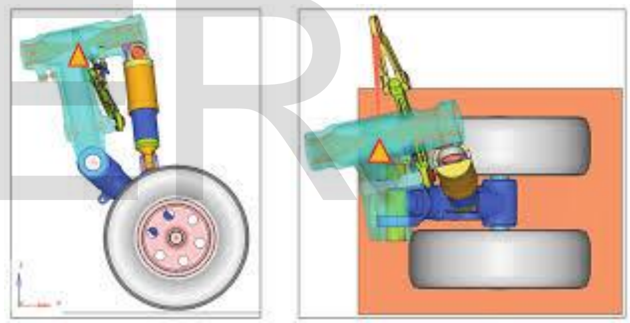

Figure 1.2: Landing Gear

1.2 Components of Landing Gears

The main component of landing gear system includes shock absorber, strut, torque arm, extraction and retraction system, brakes and wheels. Shock absorber is used to absorb the impact load during landing of an aircraft. And main function of Strut is to carry the weight of aircraft, placed above the shock absorber. Torque arm is a part of shock absorber strut which is used to prevent the piston rod from twirling (i.e. spin quickly) relative to the cylinder. Brake assembly used to brake the wheels while touching the ground. These brakes are operated either pneumatically or hydraulically.

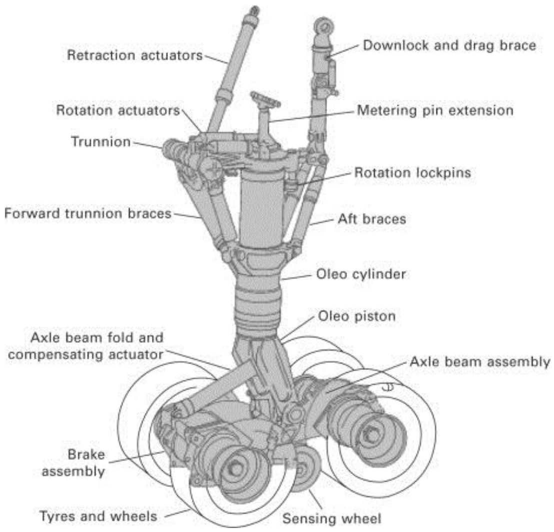

Figure 1.2: Components of Landing Gears

2. STRENGTH TEST

2.1 Test Specimen

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

2.2 Tests

The following tests are carried out:

- drag load cases Spin up case Vertical and
- Rare spring case
- Side Vertical and 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. Simulating the wheel with fully machined block
3. Plate with hub welded 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.

Density	7.8 g/cm^3
Yield strength	250 MPa
Youngs Modulus	210 GPa
Ultimate strength	450 MPa

Table – 1 Properties of CM steel

3.2 Design of Vertical Loading

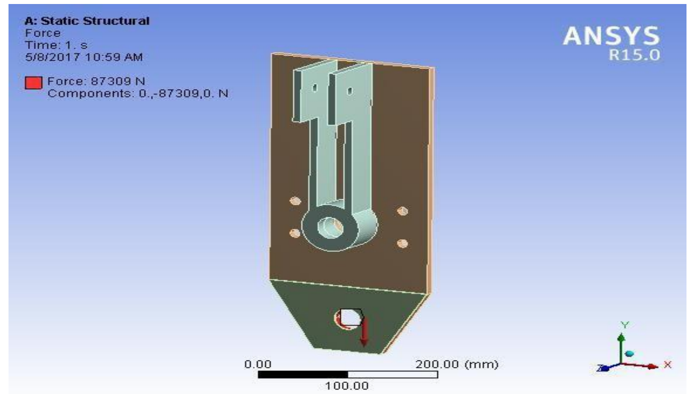

Figure 3.1: Vertical Landing bracket

Vertical load = 8900 Kg

Yield strength of material σ = 45 Kg/mm^2

Plate thickness = 10 mm

$$\text{Stress}(\sigma) = \text{Force}/(\text{ED} * \text{Thickness})$$

$$45 = 8900/(\text{ED} * 10)$$

ED = 20 mm

Since, Factor of Safety is 2.

Therefore, Eccentric Distance (ED)= 40mm

Loads	Kg
Vertical	8900 Kg
Drag	5320 Kg
Side	3010 Kg

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

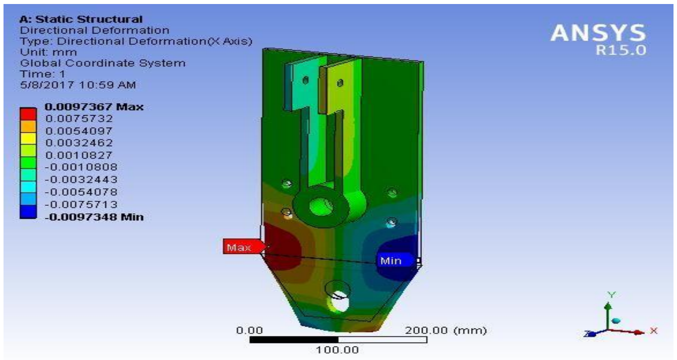

Figure - 4.1 Directional deformation of vertical load

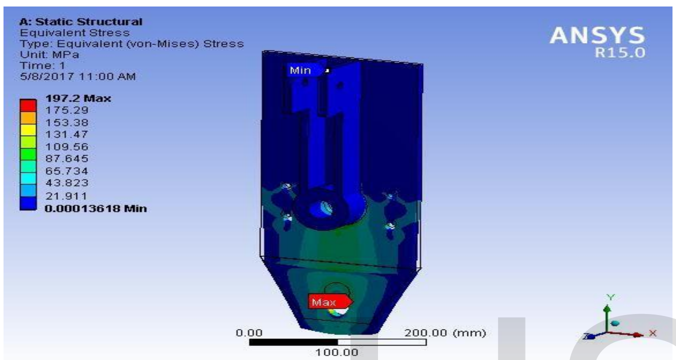

Figure - 4.2 Equivalent (Von-Mises) stress of vertical load

4.2 For Drag Loading

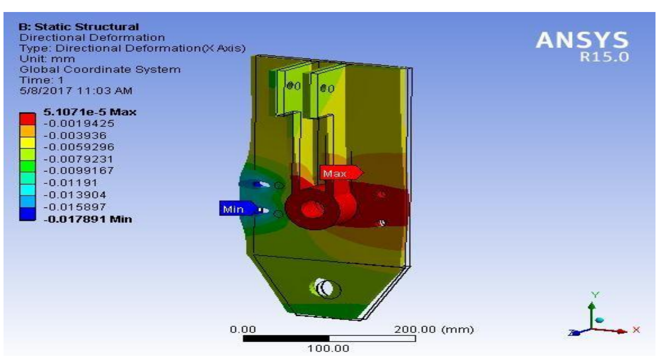

Figure - 4.3 Directional deformation of drag load

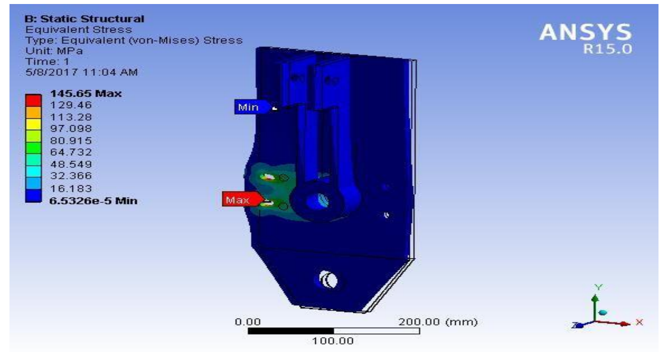

Figure – 4.4 Equivalent (Von-Mises) stress of drag load

4.3 For Side Loading

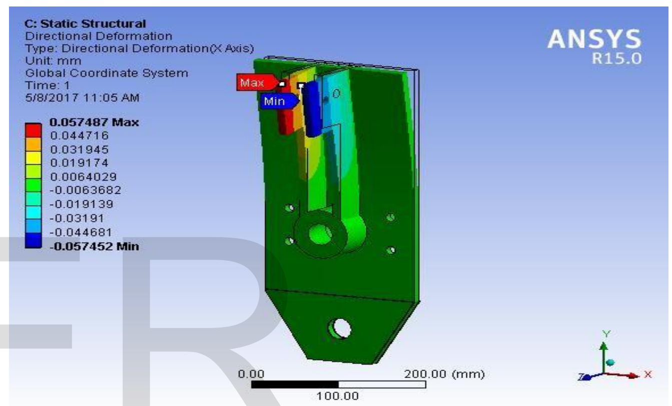

Figure – 4.5 Directional deformation of side load

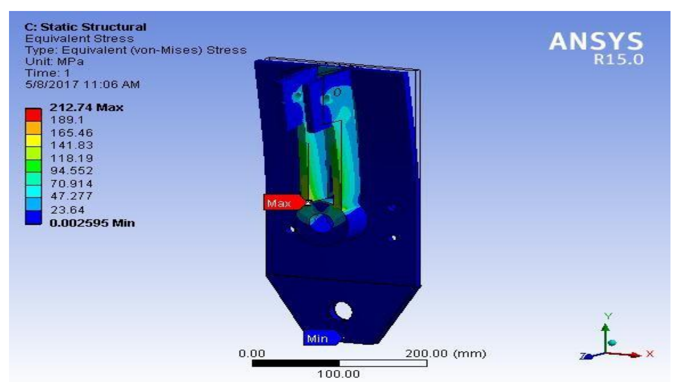

Figure – 4.6 Equivalent (Von-Mises) stress of side load

5 THEORETICAL CALCULATIONS

5.1 For Vertical Loading

σ_x = Force/ (ED × t) τ_{xy} = Force/ (Area)
= 87309/ (40 × 10) = 87309 / (450 × 10)
= 218.27 MPa τ_{xy} = 19.402 MPa

σ_y = 0 MPa Principle stress is
$\sigma_{1,2} = (\sigma_x + \sigma_y)/ 2 \pm [\{(\sigma_x - \sigma_y)/ 2\}^2 + (\tau_{xy})^2]^{1/2}$
σ_1 = 219.97 MPa and σ_2 = -1.71 MPa

Von-Mises stress equation is
$\sigma_{von} = [\{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \}/2]^{1/2}$ σ_{von}
= 220.83 MPa

5.2 For Drag Loading

For 2 holes
σ_x = Force/ (ED × t) τ_{xy} = Force/ (Area)
= 26094.6/ (24 × 10) = 26094.6 / (350 × 10)
= 108.73 MPa τ_{xy} = 7.456 MPa

σ_y = 0 MPa

Principle stress is
σ_1 = 109.23 MPa and σ_2 = -0.51 MPa
Von-Mises stress equation is σ_{von} = 109.5 MPa
5.1 For Side Loading
For 2 holes
σ_x = Force/ (ED × t) τ_{xy} = Force/ (Area)
= 14764.05/ (14 × 10) = 87309 / (450 × 10)
= 105.46 MPa τ_{xy} = 21.1 MPa

σ_y = 0 MPa Principle stress is
σ_1 = 109.53 MPa and σ_2 = -4.07 MPa
Von-Mises stress equation is σ_{von} = 111.62 MPa

LOADS	FEM VALUES	THEORETICAL VALUES
Vertical	197.2 M Pa	218.27 M Pa
Drag	145.65 M Pa	108.73 M Pa
Side	212.74 M Pa	111.62 M Pa

Table 2 Comparison of FEM and theoretical values

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.

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