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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).

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.

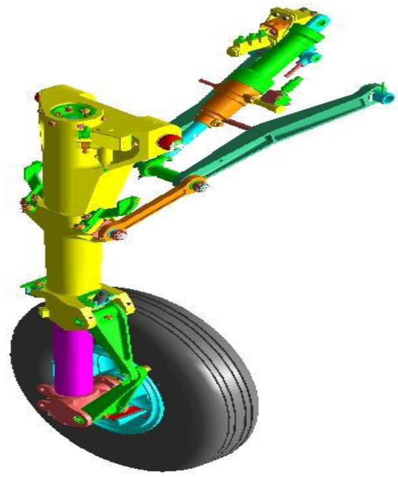

Figure 1.1 Landing Gear System

1.2 Components of Landing Gear System

The components of landing gear system mainly includes strut, shock absorber, brakes and wheels, torque arm and extraction and retraction system. The function of shock absorber is absorb the impact load during landing in recently oleo pneumatic strut is used. Strut carries the weight of aircraft, placed above the shock absorber (outer cylinder).

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 – 3.1 Properties of CM steel

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

3.2 Design of Vertical Loading

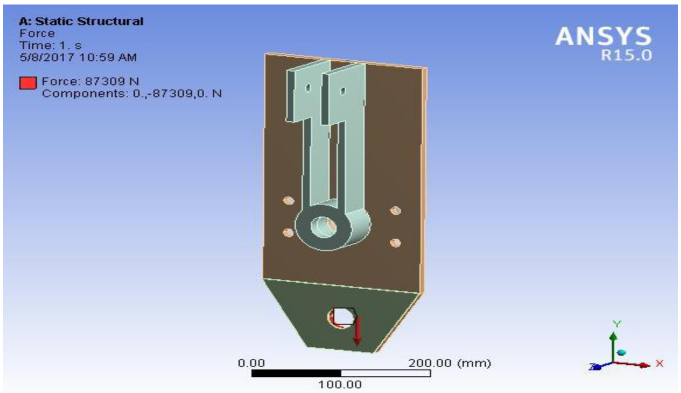

Figure – 3.1 Vertical loading bracket

Vertical load = 8900 Kg

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

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

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

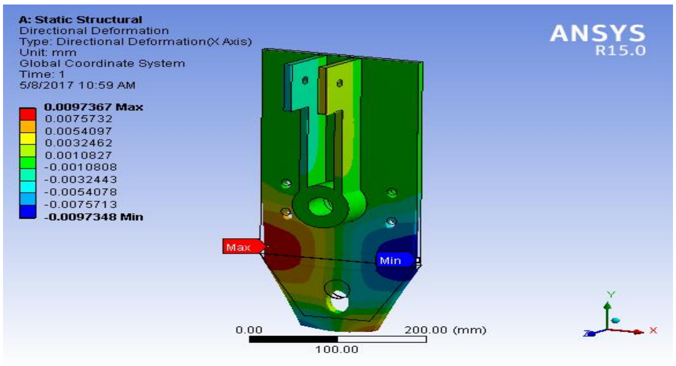

Figure - 4.1 Directional deformation of vertical loading

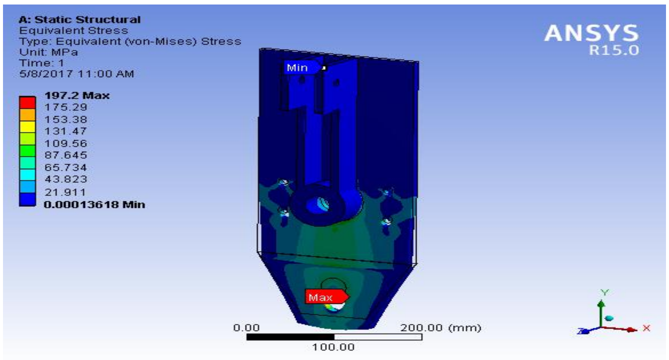

Figure - 4.2 Equivalent (Von-Mises) stress of vertical load

4.2 For Drag Loading

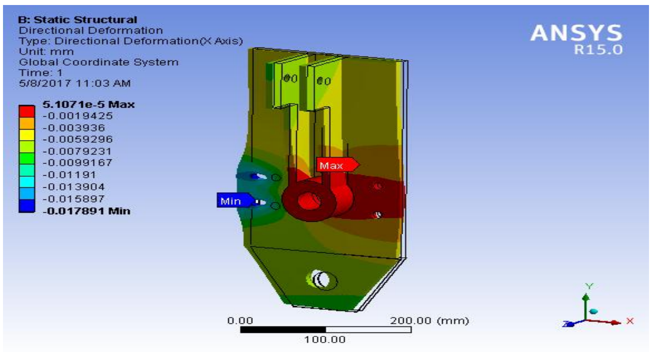

Figure - 4.3 Directional deformation of drag load

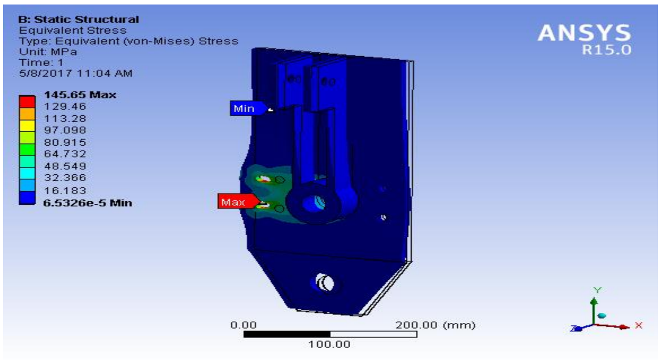

Figure – 4.4 Equivalent (Von-Mises) stress of drag load

4.3 For Side Loading

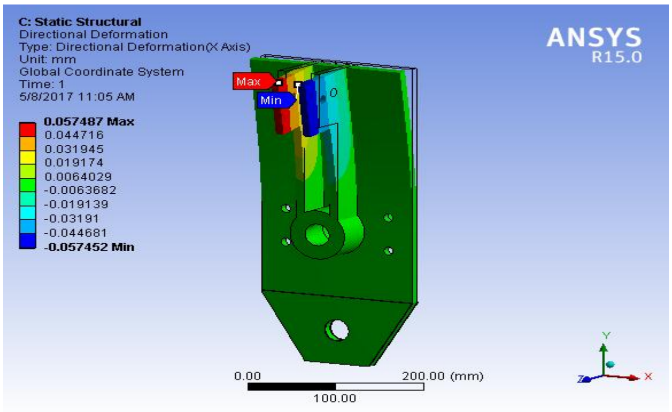

Figure – 4.5 Directional deformation of side load

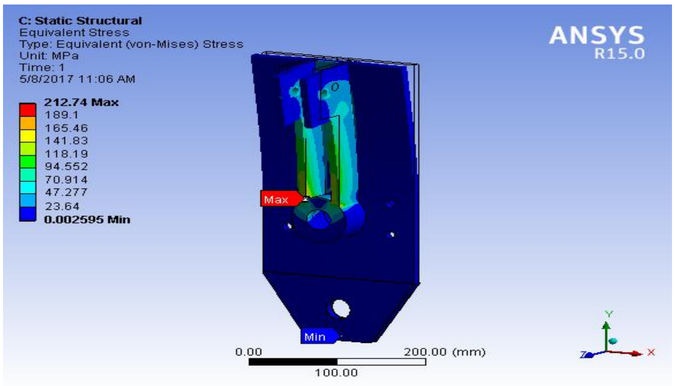

Figure – 4.6 Equivalent (Von-Mises) stress of side load

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

5.1 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

Table 5.1 Comparison of FEM and theoretical values

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

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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