International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 11, Issue 4 (Jul.-Aug. 2022), PP. 38-44

Fatigue Analysis of Aircraft Main Landing Gear

Binayak Das[1], Kumargourab Das[2], Sundar Gopal Pattanaik[3], Nihar Ranjan Panda[4]
[1]Asso. Professor, [2]Asst. Professor, [3,4]Student
Department of Mechanical Engineering Einstein Academy of Technology and Management
Bhubaneswar, Khurdha Odisha, India

Abstract: *The main landing gear (MLG) of an aircraft is subjected to high cyclic loading due to takeoff, landing, taxiing, and ground operations, making fatigue failure a major concern for structural integrity and flight safety. This study focuses on assessing fatigue behavior in the MLG, identifying critical stress regions, and proposing failure prevention strategies.*
A combination of experimental testing and computational analysis is used to evaluate fatigue life. Strain gauge instrumentation is applied to MLG components during simulated loading conditions, replicating real-world operational stresses. Finite Element Analysis (FEA) is conducted to predict stress concentration zones, crack initiation points, and fatigue crack growth rates. Additionally, non-destructive testing (NDT) techniques, such as ultrasonic testing and radiographic inspection, are employed to detect early-stage fatigue cracks.
The results indicate that stress concentrations around pivot points, attachment fittings, and shock struts significantly contribute to fatigue failure. Factors such as material selection, landing impact forces, corrosion, and maintenance intervals are also examined. Design modifications, surface treatments, and optimized inspection schedules are recommended to enhance fatigue resistance and extend the service life of the MLG. This research contributes to improving aircraft safety, reliability, and cost-effective maintenance strategies.
Keywords: ANSYS, Catia V5, Landing gear,Fatigue loading, Total Deformation ,Life Cycle, Safety Factor.

I. INTRODUCTION

Landing gear is one of the primary structura omponents of the airframe. Landing gear enables the airplan l co take off .

II. MODELLING

The landing gear are the critical component in aircraft and are used to hold the aircraft in ground. The design of the landing gear is the complex one. The various parts of the landing gear are modeled in part design and are assembled using boolean operation. For the analyzing purpose and in order to get the accurate results when importing to the analysis part, the structural part of the landing is divided into solid and surface sections . Modeling of the landing normally is done using CAD packages which can be easily ported to the analysis packages.

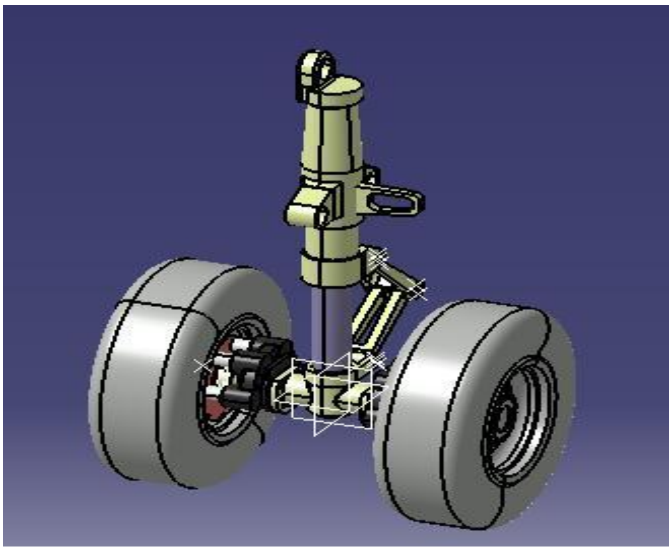


Fig 1: landing gear model

III. CALCULATION OF FORCE

To calculate the force in the main landing gear, the aircraft is assumed to be ground taxing. The entire weight of the aircraft will be acting in the C.G .For our analysis we considered the mig -23 aircraft and the maximum weight is 18030 kilograms. These weight is spread over the main landing strut and nose landing gear strut. By using the equilibrium equation the weight. $Fa\ L_n - (L_n + L_m) * Fmg = 0$

F_{mg}= (6.75*18030)/(6.57-4.589)

F_{mg}=552732N

Where,
L_n-Distance between nose landing gear from C.G point (m)
L_m-Distance between main landing gear from C.G point (m)

Fa –Total mass of the aircraft (N)

Fmg-force on the main landing gear (N)

IV. ANALYSIS OF THE LANDING GEAR

The analysis of the landing gear is performed using Ansys workbench. The catia model is imported to ansys work bench and the model is meshed. In the FEM analysis of high pressure turbine rotor blade meshing is the initial step that is to be followed after the model is being imported for the purpose of analysis. Meshing is the process that divides the model into finite number of elements for the analysis .In general, a large number of elements provide a better approximation of the solution. After meshing the model the boundary condition are specified as shown in fig 2

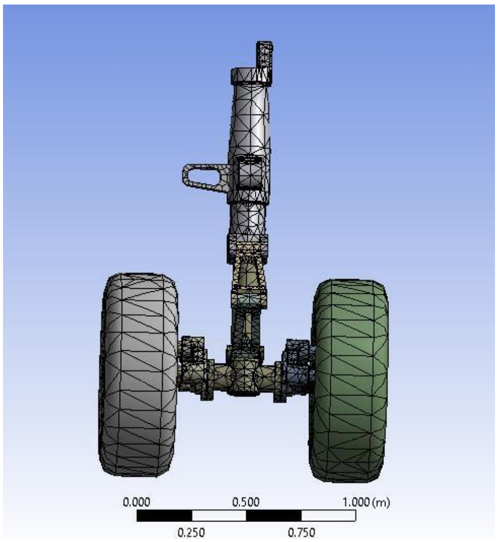


Fig 2: Meshed model of the landing gear

After meshing the boundary condition are specified. The top of the landing gear is fixed and the other point at the center of the strut is fixed. After fixing, the compressive load is applied from the bottom of the landing gear. In our analysis we applied load only from the bottom end of the strut.For our analysis the tyre part is assumed as solid surface.The boundary and loading condition of the landing gear is shown in figure 3.

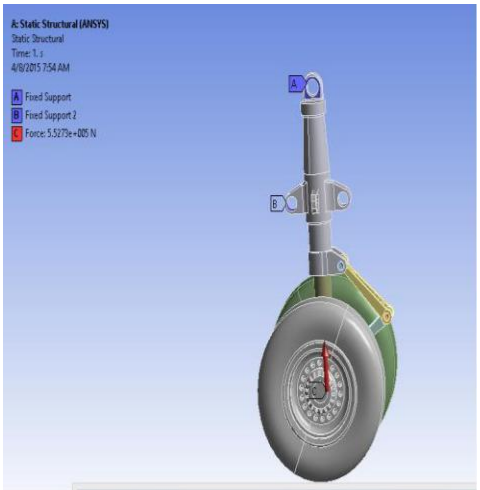


Fig 3: Support and loading condition

The analysis is carried out for titanium alloy ,alluminium alloy and carbon composite material .The material property of the materials are,

a. *Titanium Alloy (Ti553)* Modulus of elasticity =113GPa Poission ratio=0.37 Ultimate strength= 1159 MPa Yield strength=1055 MPa Compressive strength =1138

b. *Aluminium Alloy (Al 7075 T6)* Modulus of elasticity = 71.7 GPa Poission ratio = 0.33

   Ultimate tensile strength = 572 MPa Tensile yield strength = 503 MPa

c . *Carbon Composite*

   Youngs modulusl = 70 GPa

   Poission ratio = 0.1

   Ultimatre tensile strength = 600 Mpa In plain shear strength = 90 MPa Ultimate compressive strength = 570 MPa

V. RESULTS AND DISCUSSION

a.)Titanium Alloy (Ti5553)

The three solution for the titanium alloy is taken .The three solution are,

1.Total deformation during impact loading

2.The stress life of the landing gear

3.The safety factor of the landing gear.

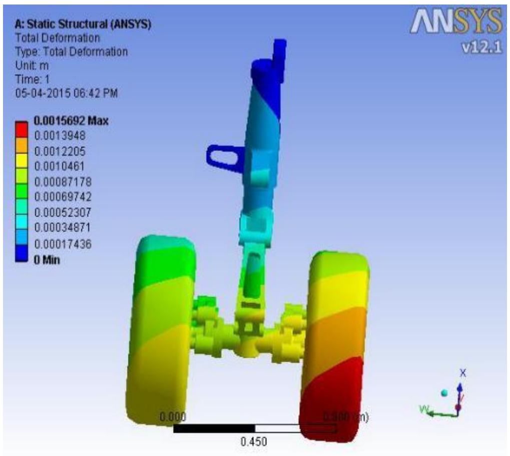


Fig 4: Total deformation of the landing gear

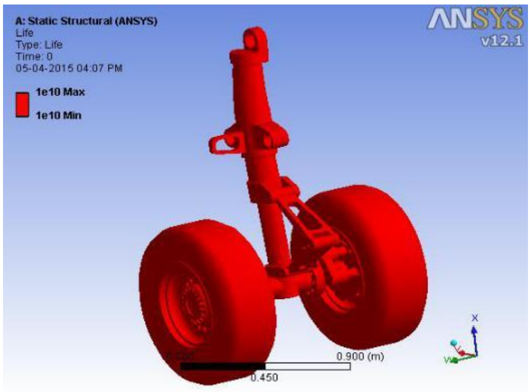
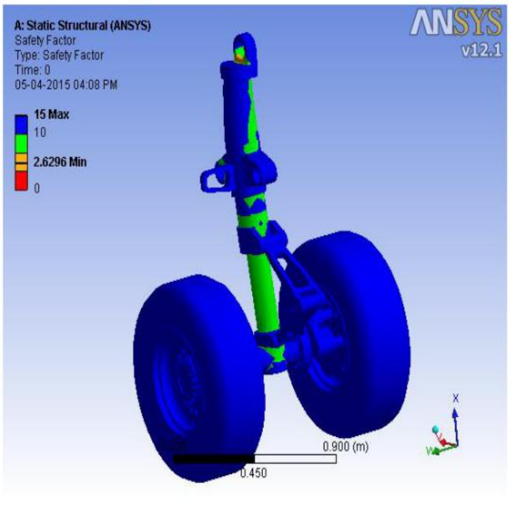


Fig 5: Fatigue life of the landing gear



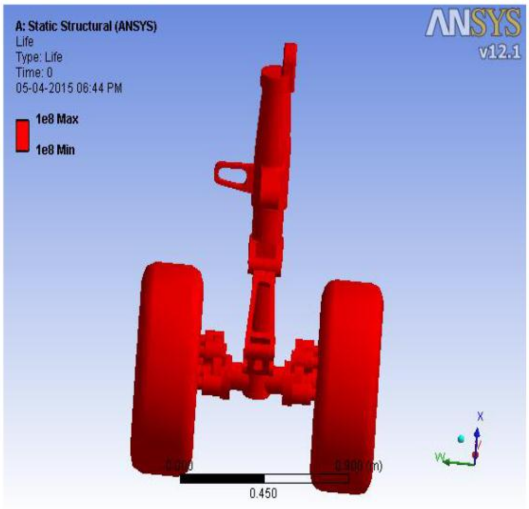


Fig 6: Safety factor of the landing gear

Fig.8: Fatigue life indication of landing gear

Object Name	Life	Damage	Total Deformation	Safety Factor
Design Life	1.e+010 cycles			
Minimum	1.e+009 cycles	0	0	2.6296
Maximum	1.e+010cycles	0.5	0.001596 m	15

Table 1: Detailed analysis information of titanium alloyed landing gear

b.)Aluminium Alloy

The three solution for the aluminium alloy is taken .The three solution are,

1.Total deformation during impact loading

2.The stress life of the landing gear

3.The safety factor of the landing gear.

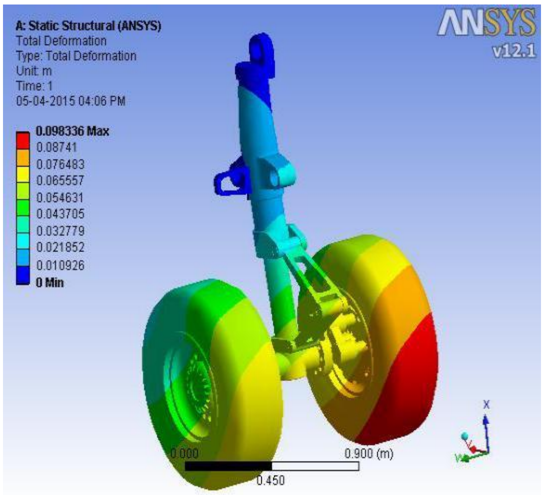


Fig 7: Total Deformation of landing gear

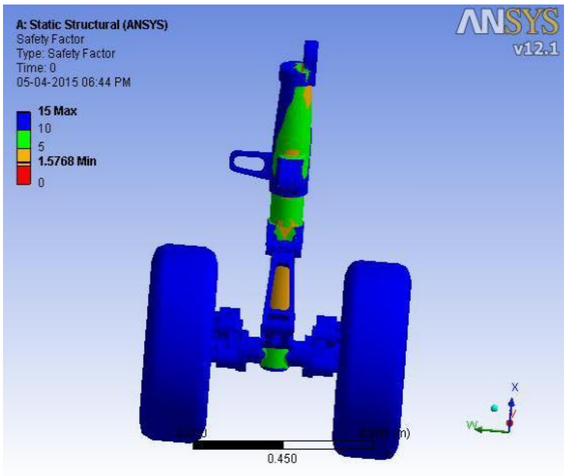


Fig.9: Safety factor of landing gear

Object Name	Life	Damage	Total Deformation	Safety Factor
Design Life	1.e+008 cycles			
Minimum	1.e+007 cycles	0	0	1.5768
Maximum	1.e+008 cycles	3	0.0098336 m	10

Table 2: Detailed analysis information for Aluminium alloy

c.) Carbon Composite Material

The three solution for the composite material is taken .The three solution are,

1.Total deformation during impact loading

2.The stress life of the landing gear

3.The safety factor of the landing gear.

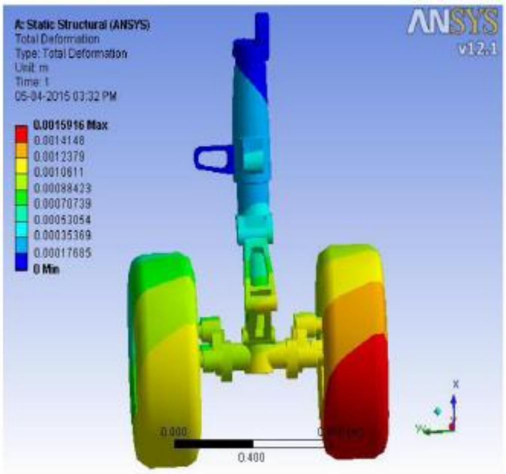


Fig .10: Total Deformation of landing gear

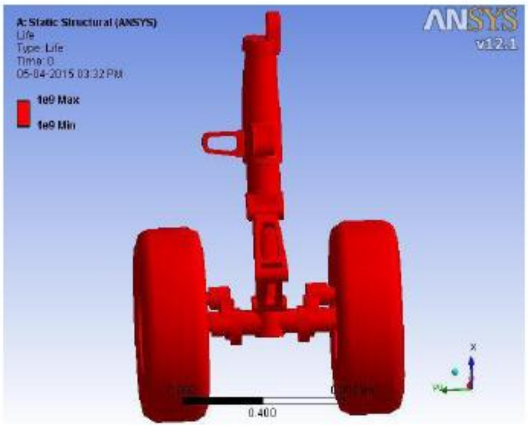


Fig .11: Fatigue life of landing gear

Object Name	Life	Damage	Total Deformation	Safety Factor
Design Life	1.e+09 cycles			
Minimum	1.e+008 cycles	0	0	2.015
Maximum	1.e+009 cycles	1	0.005482 m	10

Table. 3: Detailed analysis information for carbon composite

5. CONCLUSION

From the analysis the following conclusion is made,

S.No	Titanium Alloy	Aluminium Alloy	Composite
Total Deformation(m)	0.001596	0.009836	0.005482
Damage	0.5	3	1
Life	1*10^10 cycles	1*10^8 cycles	1*10^9 cycles
Safety Factor	2.63	1.57	2.01

Table .4: Result Comparison

The table 4 shows that the titanium alloy has more no of life cycles when compared to aluminium and composite material. The titanium alloy has more safety factor, this indicates that the titanium landing gear can withstand more impact load also. This analysis shows that titanium alloy is best suitable for landing gear construction.

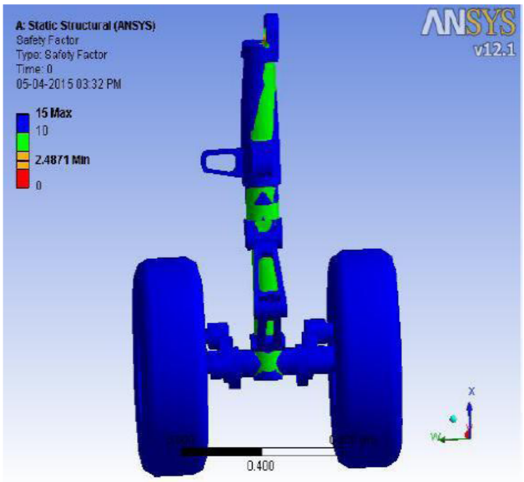


Fig 12: Safety factor of landing gear

6. REFERENCE

1. 1.Andrzej Leski, Slawomir Klimaszewski, Marcin Kurdelski,EngOpt (2008) ,"Optimization of Fatigue Life of the PZL-130 Orlik's Structure", Air Force Institute of Technology, Warsaw, Poland.
2. Marcin Kurdelski Andrzej Leski (2011) ," Fatigue of Aircraft Structures" ,Air Force Institute of Technology, Warsaw, Poland.
3. .P.Mohanraj1, S. Balaji2, S. Senthilkumar3 (2013)," Fatigue Analysis In Aircraft Landing Gear Axle Shaft To Develop The Life Cycles".PG scholar,Department of Aeronautical Engineering, Nehru institute ofengineering and technology
4. .Prasad Kabade ,1 Ravi Lingannavar (2013)," Design and Analysis of Landing Gear Lug attachment in an Airframe" PG student, Dept. of Mechanical Engineering, KLE Dr.MSSCET, Belg aum' Karnataka, India[1]
5. .Purkar T. Sanjay and Pathak Sunil , (2012),"Analysis of Crack Initiation in Fretting Fatigue Specimen"Swami Vivekanand College of Engineering' Indore
6. .PG student, Dept. of Mechanical Engineering, KLE .MSSCET Vol. 2, Issue 10, October 2013, PG student, Dept. of Mechanical Engineering KLE, MSSCET, Belgaum, ,Karnataka, India[1]
7. .1R RAVI KUMAR,2P. K DASH, 3S R BASAVARADDI,"Design And Analysis Of Main Landing Gear Structure Of A Transport Aircraft And Fatigue Life Estimation For The Critical Lug",1Product Design and Mfg, Visvesvaraya Technological University, Belgaum, India.[2] Chairman, Bangalore Aircraft Industries Pvt. Ltd., Bangalore.