ISSN: 2278-0181
NCRAIME-2015 Conference Proceedings

# Fatigue Analysis of Aircraft Main Landing Gear

Gokulraja V[1], Kumar K[2],
Karthikeyan A[3], Veeramani S[4]
UG Scholar[1,2], Associate Professor[3], Assistant Professor, Department of Aeronautical Engineering, Excel Engineering College, Namakkal, Tamilnadu, India

***Abstract:*** **The current work includes the design and analysis of the main landing gear of the fighter jet aircraft. A typical landing load case will be assumed for which structural analysis. During the ground operation of the aircraft various types of load will be encountered. Among various types of load, the following loads are focused for fatigue analysis**

**i. Impact load**

**ii. Fatigue load**

**each of these loads will cause axial compression and tension on the wheels and strut of the landing gear. In this work the landing gear model of the fighter aircraft is modeled using Catia V5 Software .The model is imported to Ansys software, the impact and fatigue analysis is carried out by assigning different material property to the landing gear. From the results obtained the comparison of life cycles, total deformation and safety factor is done. From the comparison it is concluded that the titanium alloy has more life cycle when compared to other material.**

***keywords: Landing gear, fatigue loading, total deformation, life cycle, safety factor ..,***

## 1. INTRODUCTION

Landing gear is one of the primary structural components of the airframe. Landing gear enables the airplane to take off and land on ground. Its design considerations are significantly different .A variety of landing gear configurations and types are in use today. The most common type being tri-cycle arrangement with a nose landing gear and a main landing gear. Impact loads during landing are the main design loads for the landing gear design. Landing gears should also be checked for various other ground handling loads as specified in the regulatory requirements. The landing gear withstands the ground impact load and absorbs the impact energy and diffuses the load to the surroundings attachment.

## 2. 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.

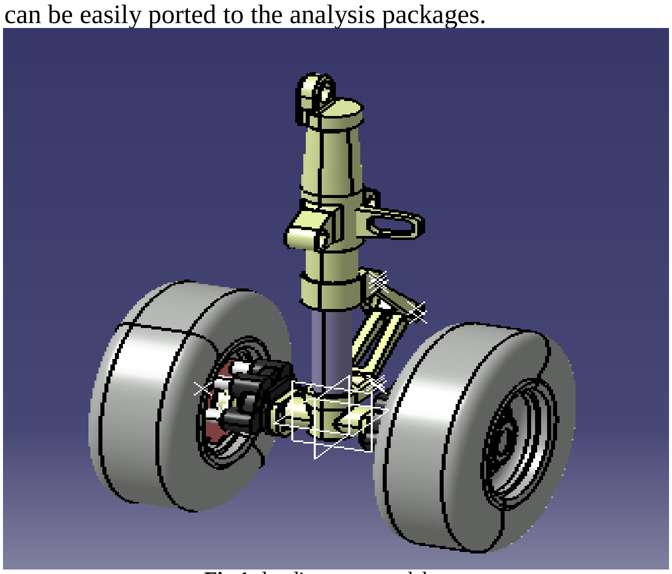

**Fig 1:** landing gear model

## 3. 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)

## 4. 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

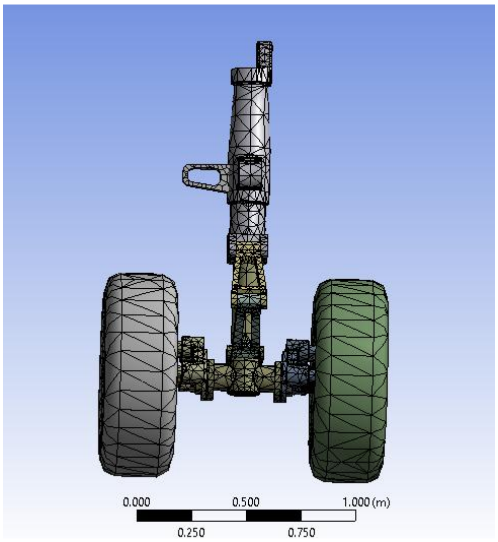


**Fig 2:** Meshed model of the landing gear

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.

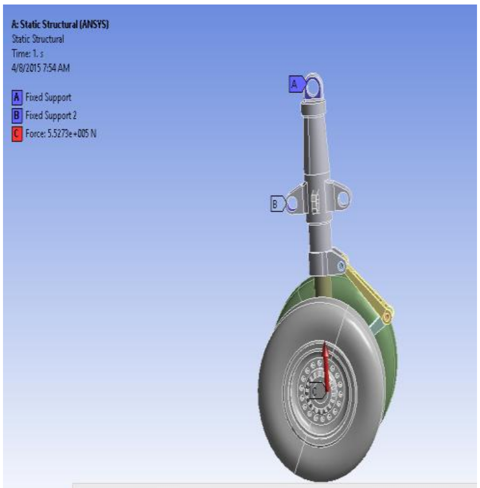


**Fig 3:** Support and loading condition

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

## 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.

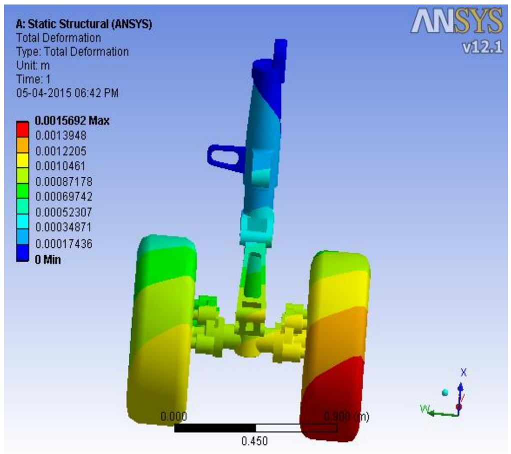


**Fig 4:** Total deformation of the landing gear

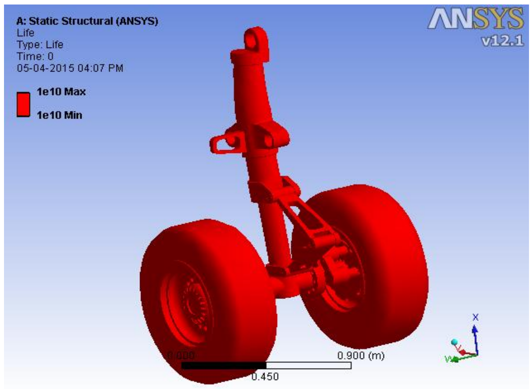


**Fig 5:** Fatigue life of the landing gear

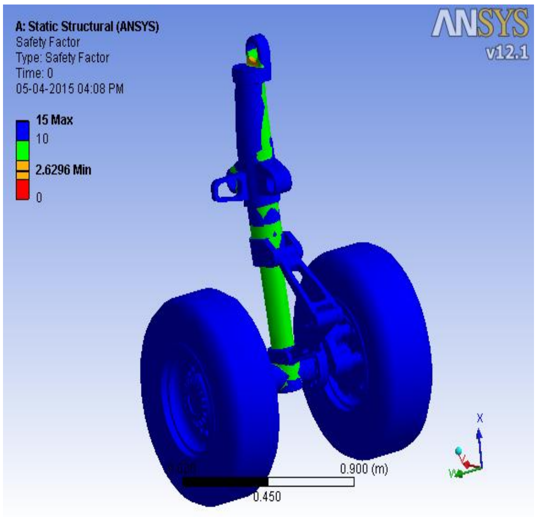


**Fig 6:** Safety factor of the landing gear

| 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.

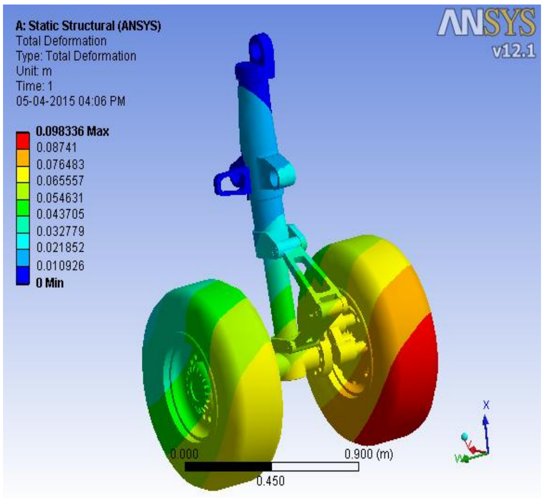


**Fig 7:** Total Deformation of landing gear

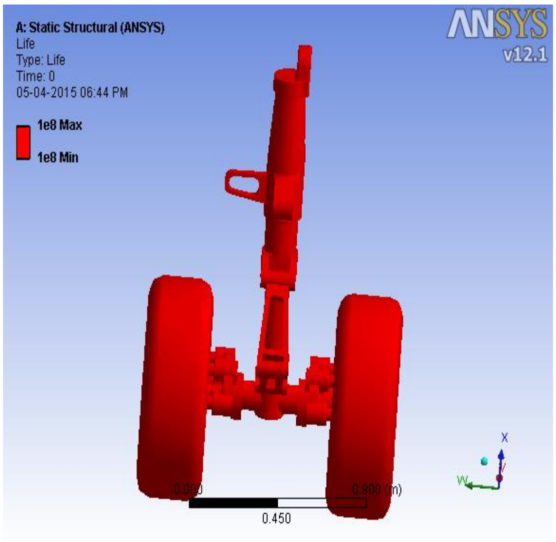


**Fig.8:** Fatigue life indication of landing gear

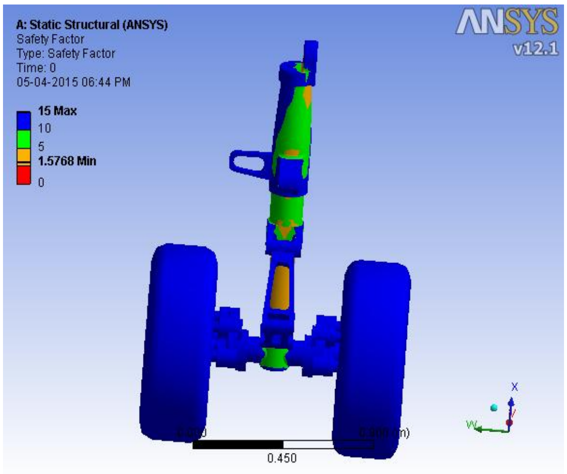


**Fig.9:** Safety factor of landing gear

| 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.

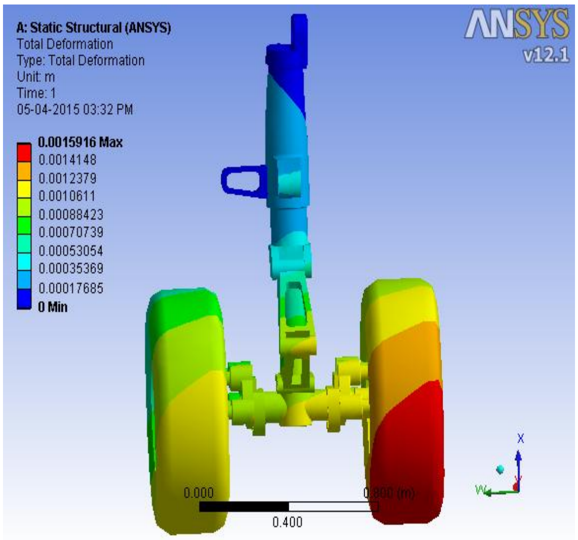


**Fig .10:** Total Deformation of landing gear

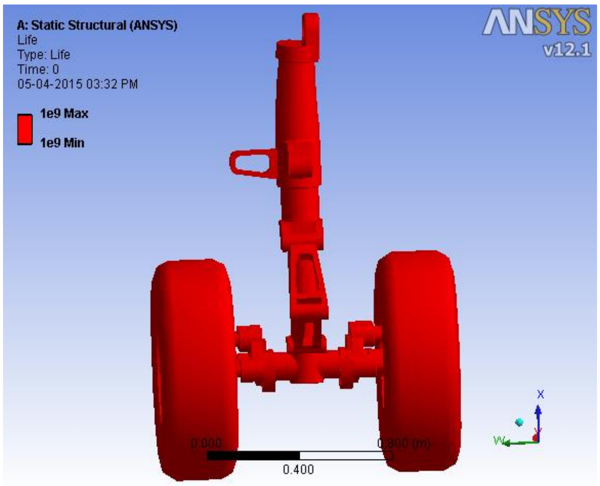


**Fig .11:** Fatigue life of landing gear

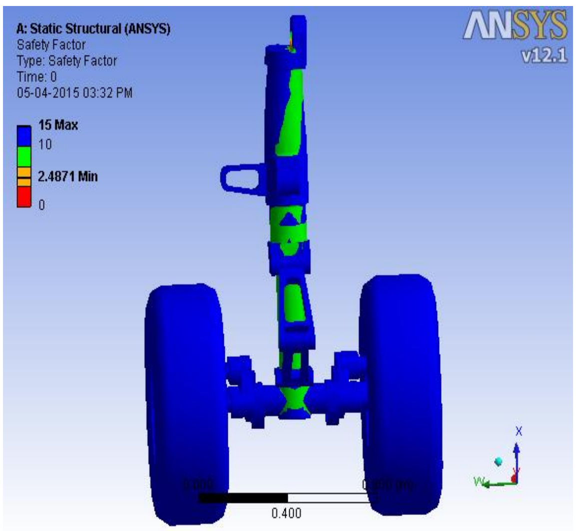


**Fig 12:** Safety factor of landing gear

| 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.

## 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 of engineering 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, Belgaum' Karnataka, India
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
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. 2Chairman, Bangalore Aircraft Industries Pvt. Ltd., Bangalore.