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Static and Dynamic Analysis of Nose Landing Gear

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ABSTRACT

Landing gear is the supporting part of an aircraft or spacecraft, and is used as principle support during takeoff, taxiing and landing. The development of new materials for landing gear is moving at rapid pace. Aerospace engine and airframe designers are constantly seeking lighter weight high strength materials which can accomplish herculean tasks such as Durability, robustness, weight reduction, cost economies, environmental responsibility and also improve performance of aircraft. Even so, steel components in landing gear are being challenged on every level. In this work, a typical landing gear of Boeing aircraft is designed and meshed using ANSYS software tool. Then structural safety, Linear static analysis and Dynamic Analysis are done by using ANSYS software to predict the phenomenon in advance so that the material and geometrical dimensions can be selected wisely. Landing gear is analyzed for the traditional metallic material Titanium 10V-2Fe-3Al and new high strength stainless steel MLX17 (X1CrNiMoAlTi12-11-2). At last results of stresses and deformations of different materials are evaluated so as to get the characteristics of a material and also for the selection of materials.

Keywords: Landing gear, Materials, Structural analysis, Deformation, Static and Dynamic analysis, Titanium 10-2-3, MXL17.

1. INTRODUCTION

Aircraft's major component that is needed to be designed is landing gear, often referred to as undercarriage. Landing gear is a structure which is used when aircraft is not flying and also helps the aircraft for smooth maneuver such as takeoff and landing. Landing gear also provides mobility to the crafts on ground and water. Generally landing gear has to bear heavy compressive load, drag load and side load. The landing gear's main role is to control the rate of compression/extension and to prevent further damage to itself as well as other parts such as airframes and components of an aircraft when load is applied. Loads can be either static or dynamic in both cases the structure must withstand the applied loads. Apart from static strength, energy absorption is an important design criterion. For small aircrafts, a lip spring type of landing gear is normally sufficient to absorb the impact energy. Oleo pneumatic landing gear is used for heavier aircraft. Faster aircraft have retractable landing gear, which folds during flight to reduce air resistance. The landing gear in aircraft contains wheels and suspension system, hydraulic or pneumatic oleo struts, for runway and rough landing surfaces.

2. AN OVERVIEW OF LANDING GEAR

In terms of design procedure, the landing gear is the last component which is designed i.e. all major components (such as wing, tail, fuselage, and propulsion system) are designed prior to the design of landing gear. According to Scientists/Researchers, the design of the new landing gear must be as simple as possible, since complex design increases the cost and weight (landing gear cost about 1.5% to 1.75% of total cost and 20% of airframe maintenance cost). However, weight also appears to be inversely proportional to the level of complexity. With the reduction in the complexity level i.e. reducing number of supports and structural members, this in turn increases the structural weight. Therefore, a balance must be reached between simplicity and weight. Landing gear are generally “safe life” components and are replaced many time during service life. Landing gear has a 20,000 hours time between overhaul and a 60,000 hours or 20 years life time. The landing gear is a relatively heavy part of vehicle, it can be as much as 7% of take-off weight, but more typically is 2.5-5%.

3. DESIGN OF LANDING GEAR

It is not always easy to design a landing gear of aircraft/spacecraft. Complexity in design often arises due to Geometry adaptation, simple kinematics, or a longer service life. However, the landing gear should perform its work while being as discreet as possible. In this work landing gear is designed by using PTC CERO and CATIA software.

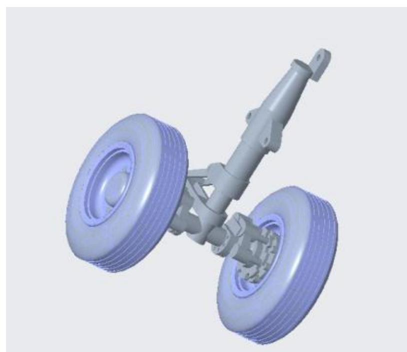


Fig.1 Landing gear assembly

4. CAUSES OF FAILURES OF LANDING GEAR

The landing gear is the part which is subjected to high stress, the fracture in joints and parts leads to serious consequence. Mechanical failure occurs in landing gear due to excessive deflection, Thermal shocks, Impact, Creep, Relaxation, Brittle fracture, Ductile fracture, Wear, Spring failure, Corrosion, Stress corrosion, Cracking and Fatigue. From this it has been found that there is a need to overcome problems associated with requirements such as strength and stiffness of landing gear at the same time it should avoid structural damage while landing. To solve this problem, Researchers have also proposed some materials such as aluminum, titanium, Mg, steel alloy, stainless steel etc. which are able to withstand the weight impact of the aircraft

5. MATERIAL SELECTION

Two types of materials are used for obtaining the best results. The materials are:

5.1 Titanium and Titanium Matrix Composites (Titanium 10V-2Fe-3Al)

Over the years, titanium metal matrix composites (Titanium 10V-2Fe-3V) have been considered and developed further for use in aircraft engine and airframe applications. For airframes, the high specific modulus of Titanium has been the impetus as it can reduce up to 600 pounds in aircraft. Ti 10V-2Fe-3Al is also known as Ti10-2-3. This is a near-beta alloy used in applications requiring high strength (in the 180,000 tensile ranges). Titanium10-2-3 combines the best hot-die forgeability of any commercial titanium with excellent high strength toughness, deep hardenabilty, ductility, fracture, toughness and high cycle fatigue strength.

1. Chemical Composition

Aluminum	2.6-3.4
Carbon	0.05 max
Hydrogen 2	0.015 max
Iron	1.6-2.2
Nitrogen	0.05 max
Oxygen	0.13 max
Remainder each	0.1 max
Remainder Total	0.3 max
Titanium	Balance
Vanadium	9-11
Yttrium	0.005 max

2. Properties

Density	4.65 Kg/m3
Poisson's ratio	0.32
Modulus of Elasticity	107 GPa
Ultimate tensile strength	1260 Mpa
Yield tensile strength	1170 Mpa

5.2 Stainless Steel MLX17 (X1CrNiMoAlTi12-11-2)

This New high strength stainless steel offer high fracture toughness and excellent corrosion resistance. Researchers and experts, claims that the strength of MLX17 high strength stainless steel is such that "a 1mm diameter wire could be strong enough to lift a car". In this material aluminum and titanium are used for hardening. MXL17 has excellent mechanical properties in both longitudinal and transverse directions, excellent fatigue resistance and good balance between strength and toughness properties. In addition to this, it doesn't require toxic cadmium surface treatments like other steels and stainless steel is recyclable. This material has equal robust and reliable characteristics when compared with their predecessors. The main advantage of this material is that it reduce weight and lowers fabrication cost.

1. Chemical Composition

Carbon	≤0.02
Chromium	12.00
Nickel	11.00
Molybdenum	2.00
Aluminum	1.50
Titanium	0.30

2. Properties

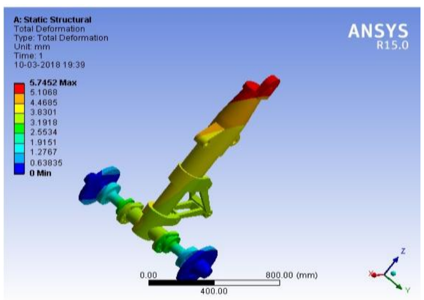
Density	7.8 Kg/m3

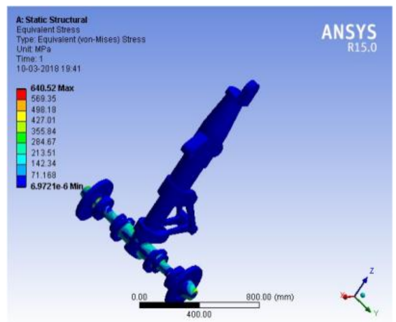
Poisson's ratio	0.32
Modulus of Elasticity	195 GPa
Ultimate tensile strength	1750 Mpa
Yield tensile strength	1650 Mpa

6. EXPERIMENTAL RESULTS

In this paper, the landing gear is analyzed for the following materials to find out the best material. Vertical load applied to the designed landing gear in all the cases is -250000 N. This value is referred from Boeing 747 aircraft.

6.1 Static analysis of Titanium alloy





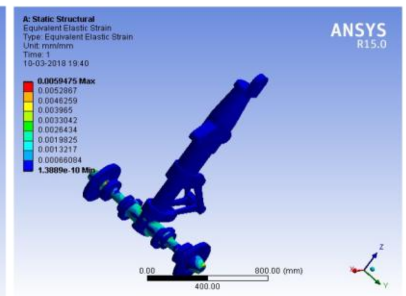
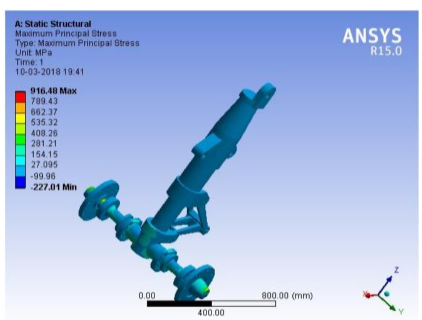


Fig.2 Titanium Alloy – Deflection *Fig.3 Titanium Alloy - Stress distribution* *Fig.4 Titanium Alloy – Strain*



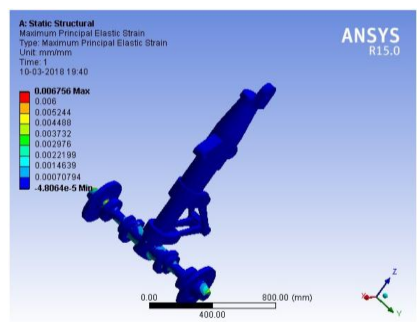


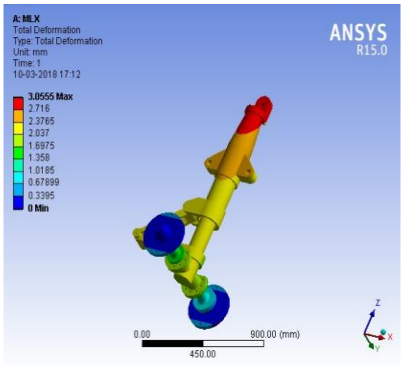
Fig.5 Titanium Alloy - Maximum Principle Stress *Fig.6 Titanium Alloy - Maximum Principle Strain*

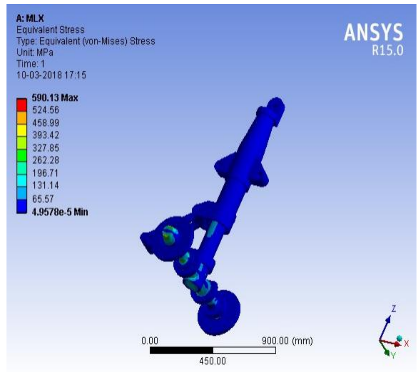
The figures (2),(3),(4),(5) and (6) shows the Deformation, Equivalent stress, Equivalent strain, Maximum principle stress and Maximum principle strain of whole assembly of Titanium 10Al-2Fe-3V. The Maximum and minimum value that induced in assembly are tabled below.

Table.1 Results for Titanium Alloy

Sl.no	Results	Maximum	Minimum	Units
1.	Deformation	5.74	0	Mm
2.	Equivalent stress	640.52	6.9721E-6	MPa
3.	Equivalent strain	0.0059475	1.3889E-10	
4.	Maximum Principle stress	916.48	-227.01	MPa
5.	Maximum Principle strain	0.006756	-4.806E-5	

6.2 Static analysis of MXL17 (X1CrNiMoAlTi12-11-2)





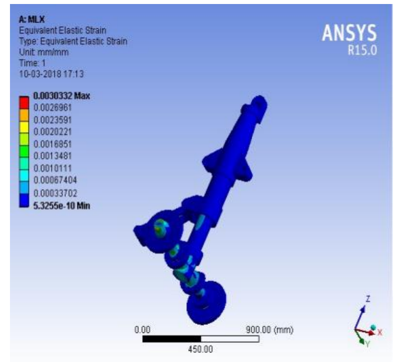
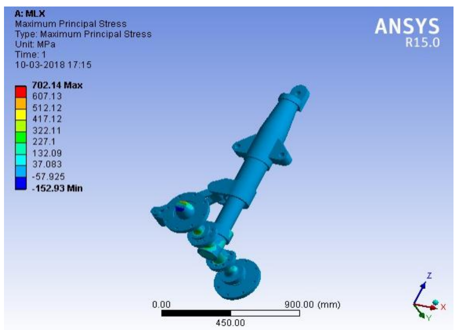


Fig.7 MXL17 – Deformation *Fig.8 MXL17 - Stress distribution* *Fig.9 MXL17 - Strain*



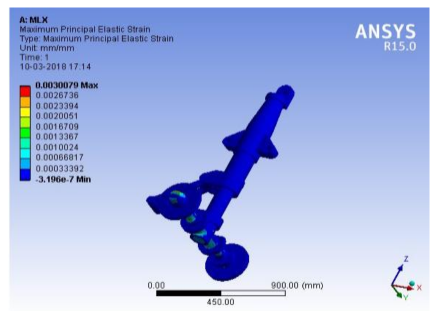


Fig.10 MXL17 - Maximum Principle Stress *Fig.11 MXL17 - Maximum Principle Strain*

The figures (7),(8),(9),(10) and (11) shows the Deformation, Equivalent stress, Equivalent strain, Maximum principle stress and Maximum principle strain of whole assembly of MLX17(X1CrNiMoAlTi12-11-2). The Maximum and minimum value that induced in assembly are tabled below.

Table.2 Results for MLX17(X1CrNiMoAlTi12-11-2)

Sl.no	Results	Maximum	Minimum	Units
1.	Deformation	3.055	0	Mm
2.	Equivalent stress	590.13	4.957E-5	MPa
3.	Equivalent strain	0.0030332	5.3255E-10	
4.	Maximum Principle stress	702.14	-152.93	MPa
5.	Maximum Principle strain	0.0030079	-3.116E-7	

7. DYNAMIC ANALYSIS

Using Ansys workbench, dynamic analysis of nose landing gear is done. The material selected in this analysis is MLX17. Each joint between the landing gear parts is specified and a load of 250000N is given. After running the simulation, the results for maximum velocity and deformation are obtained.

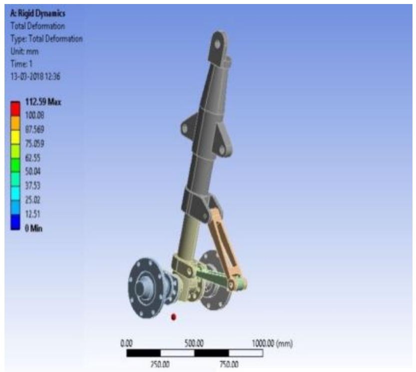


Fig.12 Total deformation

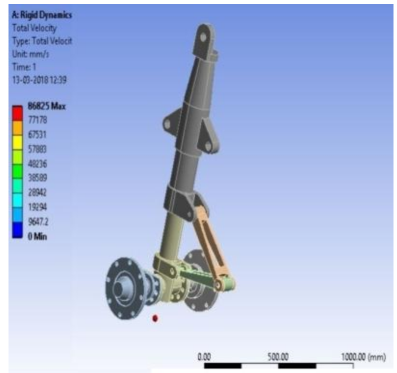


Fig.13 Total velocity

The figures (12), (13) show the Total Deformation, velocity of whole assembly of MLX17 (X1CrNiMoAlTi12-11-2). The Maximum and minimum value that induced in assembly are tabled below.

Table.3 Results for MLX17

	Maximum	Minimum	Units
Total Deformation	112.59	0	mm
Maximum Velocity	86825	0	mm/s

8. CONCLUSION

Initially, a typical landing gear of Boeing 747 aircraft is designed with CATIA and CREO software tool, and then analyzed for static and dynamic safety using ANSYS software. The maximum possible load (250KN – 1/3 of Maximum landing load of Boeing 747) is given as design load. Landing gear is analyzed for the traditional metallic materials Titanium 10Al-2Fe-3V and MLX17 (X1CrNiMoAlTi12-11-2). While comparing the results of the above mentioned materials, MLX17 (X1CrNiMoAlTi12-11-2) has the maximum factor of safety, and the minimum value of maximum stress deflection. So, the modeled landing gear will be safer for the MLX17 (X1CrNiMoAlTi12-11-2) material to avoid the structural failure.

REFERENCES

1. M. Imran, S. A. R. M, M. Haneef, P. G. Student, M. Engineering, and G. College, “Static and Dynamic Response Analysis for Landing Gear of Test Air Crafts,” vol. 3, no. 5, 2014.

2. M.Chandru, M.Durairaj, S.Saravanakumar, S.Kaliappan (2015) “internal flow analysis of submersible pump impeller using CFD”, International Journal of Applied Engineering Research, Vol. 10 No.33, PP- 25937- 25944.

3. P. Kabade and R. Lingannavar, “Design and analysis of landing gear lug attachment in an airframe,” vol. 2, no. 10, pp. 5358–5370, 2013.

4. S.Kaliappan, M.D.Raj Kamal, Dr.S.Mohanamurugan, Dr. P.K.Nagarajan (2018) “analysis of an innovative connecting rod by using finite element method”, taga journal of graphic technology, Vol. 14 -2018, PP-1147-1152.

5. S. R. Basavaraddi, “Design and Analysis of Main Landing Gear Structure of a Transport Aircraft and Fatigue Life Estimation,” no. July, pp. 10–14, 2013.

6. Kumaragurubaran.J Raj Kamal M.D Kaliappan S (2015) " investigation of jet noise reduction using fan flow deflectors on CFD ", International Journal of Applied Engineering Research, Vol. 10 No.33, PP- 26003- 26010

7. A. V Gaikwad, R. U. Sambhe, and P. S. Ghawade, "Modeling and Analysis of Aircraft Landing Gear : Experimental Approach," vol. 2, no. 7, pp. 2–5, 2013.

8. Aircraft Classifications Dr. Antonio A. Trani Associate Professor Department of Aeronautical Engineering VirginiaTech.

9. Design optimization of landing gear of an aircraft- IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 01-04

10. Aircraft Structures for engineering students Third Edition: T H G Megson.

11. Kaliappan S, Revanth Raam AP , Charan B, Asswin S , Mohammed Ibrahim SM , Dr.T.Mothilal , M.D.Rajkamal , "modal and kinematic analysis of a connecting rod for different materials" , International Journal of Pure and Applied Mathematics (IJPAM) , Volume 119 No. 12 2018, 14599-14608.

12. Finite Element Analysis of a Nose Gear During Landing" (2010). UNF Theses and Dissertations Paper 215.

13. Chapter 11; Aircraft Design: A conceptual approach by Daniel P Raymer.

14. Modeling and Analysis of aircraft landing gear: experimental approach", International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064.

15. Numerical Investigation of Landing Gear Noise: Wen Liu.

16. S.Kaliappan, G R Vignesh, N R Vigneshwaran, R Giritharan, Dr.T.Mothilal, M.D.Rajkamal (2018), "static analysis of connecting rod in a single cylinder diesel engine", International Journal of Pure and Applied Mathematics (IJPAM) , Volume 119 No. 12 2018, 14037-14043.