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Linear Buckling Analysis of Landing Gear

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Abstract*: In an aircraft the landing gear is the most critical system which acts as suspension during landing and take-off. During this, it experiences very large magnitude of impact load which is mostly compressive in nature. Hence, a major concern in this structure is buckling failure. Buckling is a mode of failure in which compressive forces act along the axis of the component. Buckling can cause catastrophic deformation of the component for slight increase in load acting on the body. Many a time buckling is the deciding factor for allowable stress. So, the buckling strength of the material used for landing gear should be sufficiently high enough to resist failure. Good corrosion resistance and low density makes Ti-6Al-4V (also called TC4) the most commonly used material for the landing gear. This paper deals with linear buckling analysis of landing gear and compares the result of three titanium alloys (TC4, Ti-7Al-4Mo, TIMETAL 834) for landing gear. The landing gear assembly is designed in CREO 3.0 and linear buckling analysis is performed in ANSYS 19.2.

***Keywords* : Landing gear, Linear buckling, Load multiplier, Titanium alloys.**

I. INTRODUCTION

The landing gear in aircraft is basically an assembly that supports the aircraft when it is on ground. It consists of wheels along with suspension and brake system. A landing gear comprises of system components which includes torque links, shock absorber, retraction system, bogie beam, antiskid system. Landing gear structure is subjected to very high compressive stresses during landing which makes the landing gear structure susceptible to buckling. Buckling is a mode of failure of structural member when it is subjected to compressive axial loads. Buckling causes lateral deflection which is unstable in nature. It shows significant amount of deformation for slight increase in existing axial load. Buckling is not about exceeding the maximum compressive stress, rather it is about finding stable alternative geometrically at being compressed. In past, nose landing gear buckling analysis is carried out in MSC PATRAN for Ti5553 only[11].

The material used for landing gear has considerable influence on its structural configuration. Though it is necessary to design landing gear with minimum weight and volume, it must possess sufficiently high magnitude of crippling load. The landing gear is required to have same service life as of the aircraft. For a given load, the value of load multiplier gives the critical load at which the structure would buckle. Titanium alloys provide outstanding mechanical properties and high strength-to-weight ratio. The TIMETAL 834 has an added advantage of good castability an weldability.

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II. METHODOLOGY

The detailed process has been shown in fig. 1.

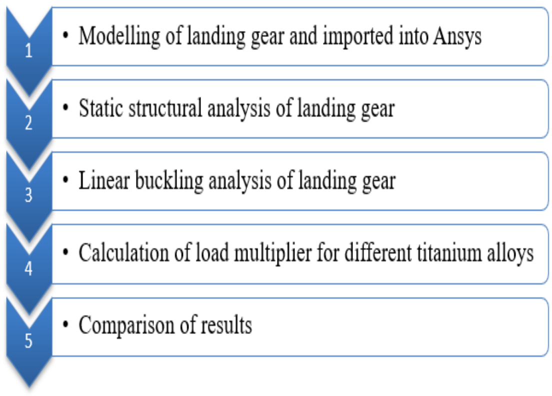

Fig. 1.Methodology used

III. MATERIAL AND GEOMETRY

Alloys of Titanium due to their specific strength(high) have been considered as wide scope for the researchers. Two alloys of titanium (TIMETAL 834 and Ti-7Al-4Mo) are compared with frequently used Ti-6Al-4V for buckling under same loading and end conditions.

Table- I: Properties of titanium alloys

Properties	Ti-6Al-4V	Ti-7Al-4Mo	TIMETAL 834	Units
Density	4.43	4.48	4.55	g/cm^3
Young's Modulus	113.8	116	120	GPa
Poisson's Ratio	0.342	0.32	0.32	-
Tensile Yield Strength	880	827	930	MPa
Tensile Ultimate Strength	950	896	1050	MPa

Source: Matweb; August 2019

The landing gear is modelled in CREO 3.0 and imported into Ansys as IGS file.

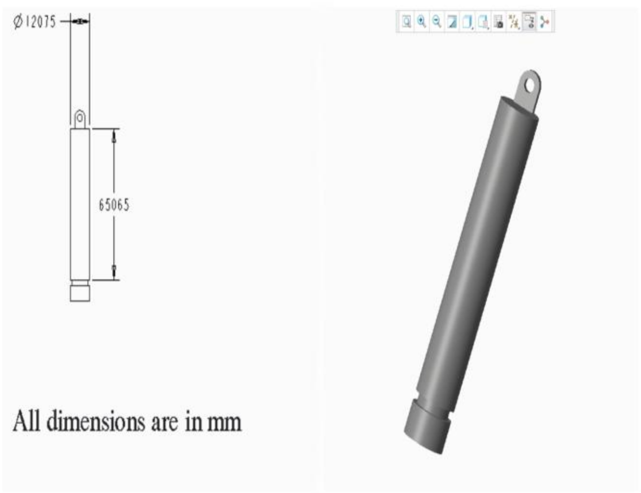

Fig. 2.Dimensions (left) and typical landing gear model (right)

IV. MESHING

Tetrahedron meshing with element size of 1373mm is used to achieve minimum aspect ratio. A uniform tetrahedron mesh is used and the model is discretized into 31258 nodes and 8235 elements.

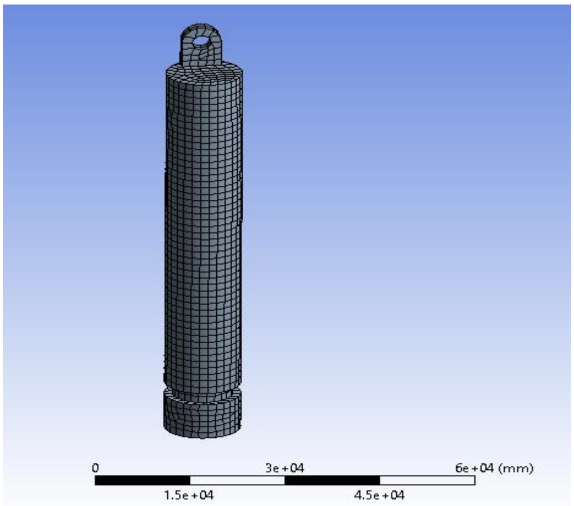

Fig. 3.Tetrahedron meshed landing gear with an element size of 1373mm

V. BOUNDARY CONDITIONS AND LOAD

Boundary conditions and loads are applied on the meshed model. A fixed support and static load of 4414.5KN are applied on top and bottom end respectively.

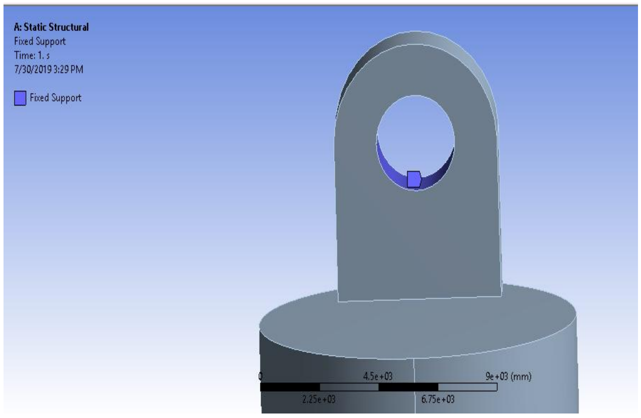

Fig. 4.Fixed supported top end

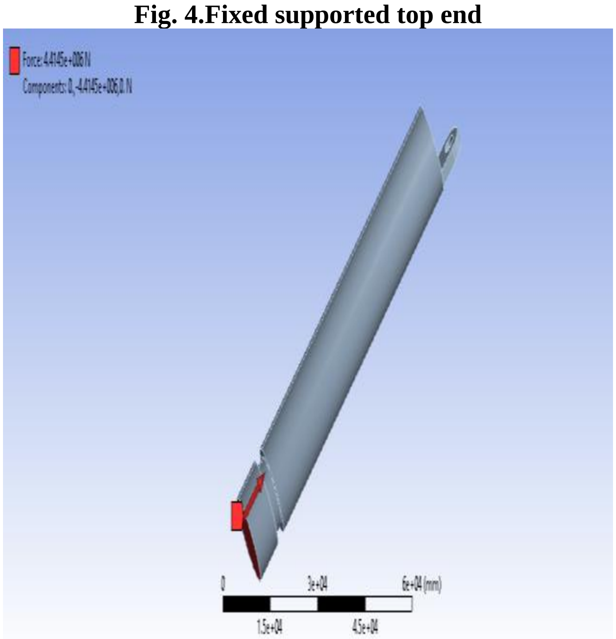

Fig. 5.Compressive force of 4414.5KN at bottom end

VI. RESULT AND DISCUSSION

The linear buckling analysis has been performed for three different Titanium alloys. The results are tabulated and compared. Fig. 5, 6, 7 shows the comparison. Table-II shows the value of load multiplier in the three cases. The magnitude of load when multiplied by the load multiplier gives an estimate of critical load or crippling load. Load multiplier is basically the factor of safety for the applied load. The commonly used titanium alloy TC4 has the least value of load multiplier. Ti-7Al-4Mo has 0.96 percent higher load multiplier value than TC4 and TIMETAL 834 has 4.265 percent higher load multiplier value than TC4 for the same load and end conditions. Hence, TIMETAL 834 has highest value of critical load.

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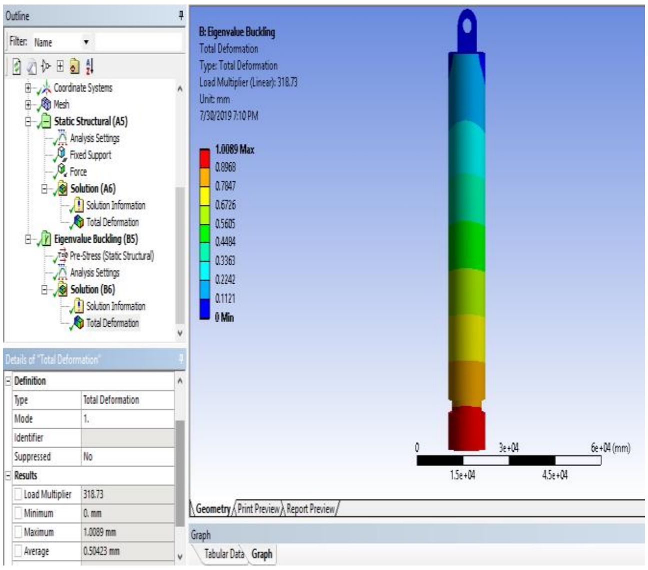

Fig. 6.Deformation under buckling for Ti-6Al-4V

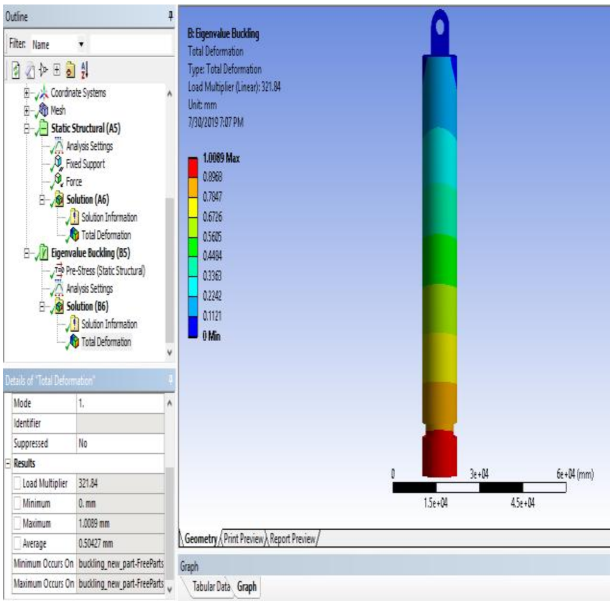

Fig. 7.Deformation under buckling for Ti-7Al-4Mo

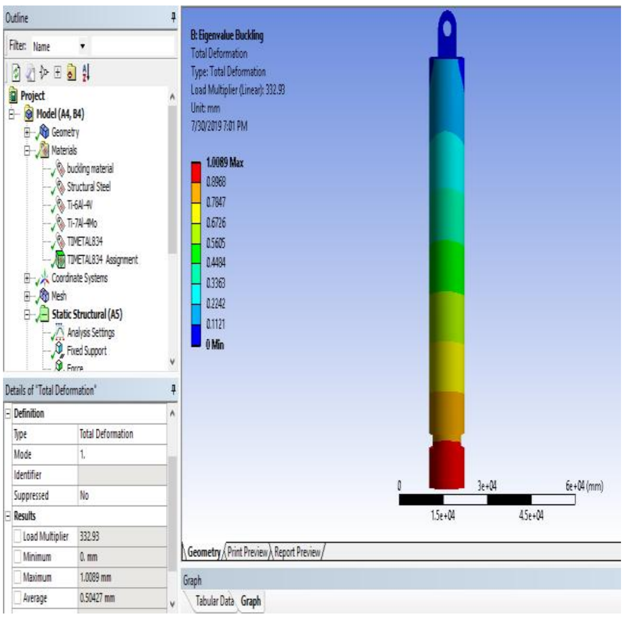

Fig. 8.Deformation under buckling for TIMETAL 834

Table- II: Results for buckling

Material	Deformation under static loading (mm)	Deformation under buckling (mm)	Load multiplier
Ti-6Al-4V	13.009	1.0089	318.73
Ti-7Al-4Mo	12.888	1.0089	321.84
TIMETAL834	12.458	1.0089	332.93

Table II shows that both Ti-7Al-4Mo and TIMETAL834 has lower deformation under same value of static loading and TIMETAL 834 has least deformation among all three.

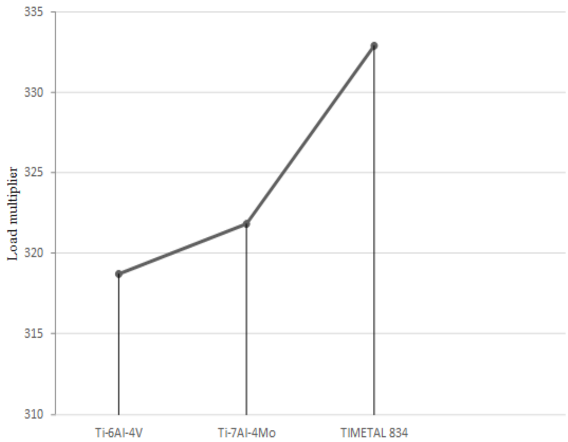

Fig. 9.Comparison of load multiplier for Ti-6Al-4V, Ti-7Al-4Mo and TIMETAL 834

VII. CONCLUSION

The modelling for the landing gear has been carried out on CREO 3.0 and after importing the model, it is analyzed for buckling for three different titanium alloys using linear buckling analysis in ANSYS 19.2. The accuracy of the solution is affected by type of mesh generated. Tetrahedron mesh is thus used in the analysis. Comparison of these alloys under buckling is done based upon the value of load multiplier obtained after analysis. The largest value of load multiplier is obtained for TIMETAL 834 keeping the same loading conditions for all cases. The crippling load obtained is 1470052.415 KN for TIMETAL 834, which is maximum of all other titanium alloys analyzed. These results shows that TIMETAL 834 is more resistant to buckling than commonly used TC4.

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