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Identification of Modal Parameters for Landing Gear using Matlab

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Abstract*: Landing gear is an assembly of various sub-systems, namely, gear, axle, hydraulic actuator and accessories and brake system. The landing gear supports the fuselage and have to bear the dead weight of the aircraft under static condition. Nowadays, retractable landing gear system is more commonly used. It is exposed to atmosphere and, hence, wind during landing and takeoff only. As wind is an inconstantly varying natural dynamic phenomenon, due to this the engineers while designing components like landing gear need to take a note of the vibrational characteristic (natural frequency) as it may induce unnecessary vibrations which may lead to irreparable damage and cause tragic failure of the component. In this paper, the modal analysis of landing gear has been carried out to find its natural frequency in MATLAB R2018a using Partial Differential Equation Toolbox and the CAD model of landing gear is created in CREO 3.0 and imported as a binary stereolithography file in MATLAB.

***Keywords* : Landing gear, MATLAB, Modal analysis, natural frequency.**

I. INTRODUCTION

The airways transport in spite of high operational cost and risk is the preferred mode of transport due to its high speed and thus lesser time for longer distances. The main function of landing gear is to provide smooth landing and make off and also an active suspension system. The landing gear ensures minimum impact of load during landing and absorbs (and dissipate) the kinetic energy during landing. The landing gear provides ground stability, to an aircraft, with controllability. It supports the dead weight of aircraft when it is not flying. The properties like high strength, light weight, shock absorption are essential for the material of landing gear. With advancements in the performance of aircrafts, designing of landing gear requires study of modal parameters, along with lightweight and strength for dynamic loading, that results in displacement which is many times that of static loading. If the force of excitation coincides with the natural frequency of the structure, the structure should be considered for redesign in such a way that the natural frequency shifts away. Jayashankar M N and Ms. Parvathy Venugopal performed operational modal analysis on a cantilever beam by giving an excitation force and extracted modal parameters to compare the experiment results with the MATLAB results [14]. In 2008, Marc Boeswald, Yves Govers, Dennis Goege and Lingmi Zhang [16] presented the results of a study in which the modal parameters are found by the vibration measurements using operational modal analysis and they analyzed two different cases to find eigenfrequencies, damping ratios and mode shapes from Taxi Vibration Testing. In 1992, George H, James, Thomas, James Lauffer and Arlo [17] developed a Natural Excitation Technique, also provided a theoretical justification for the same, for the estimation of the modal parameters with lack of complete knowledge of input forces. In 2005, Peeters, Frederik and Herman [19] discussed the application and advantages of PolyMAX method to monitor the structure of stadium during a football game by studying the data available of the stadium.

Every structure (mechanical) can resonate and even a small magnitude of force may result in deformation which can damage the structure. The Modal analysis provides an epitome of limited response of a system. In various fields like automotive, aerospace, civil engineering the modal analysis is used commonly these days as they are subjected to unnecessary vibrations due to excitation from the currents of water, wind, sounds etc. Nowadays there are various tools available to carry out modal analysis, each have some advantage over other. MATLAB is the tool which works on reliable code and provides fast processing. Modal analysis in MATLAB utilize Range Kutta algorithm [14].

The natural frequency (property of an object) of a system is defined as the frequency whereat the system oscillates in absence of any external force. As a frequency approaches the resonant frequency, the magnitude of the response of the system increased to infinity. The modal analysis provides these frequencies (natural frequencies) of the system. In real world, a system may have more than one natural frequency and the system responds differently at these different frequencies. The behaviour of system at particular frequency is known as mode shape.

II. METHODOLOGY

The process outline has been shown in the fig. 1. A structure model for modal analysis in MATLAB first then the STL file of landing gear assembly is impoted to apply the structural properties and boundary conditions. Then the component is discretized into small elements and finally the solutions has been found.

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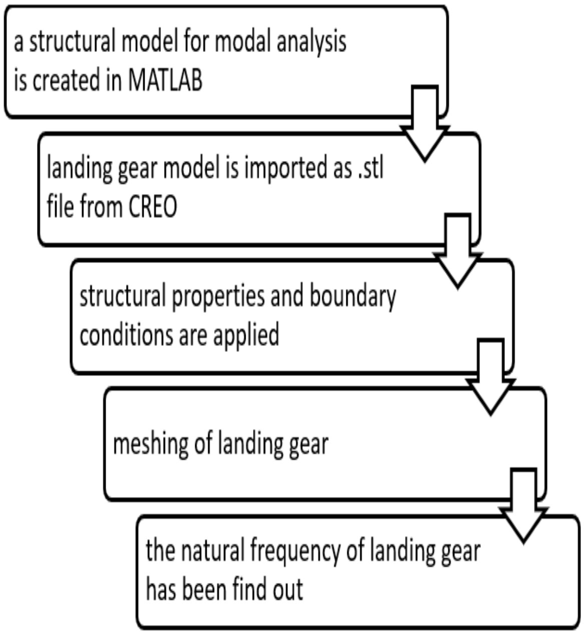

Fig. 1.Methodology

III. GEOMETRY

The model of landing gear is created in CREO 3.0. The proper deviation control is ensured to convert CAD model into binary stereolithography file, to ensure this a chord height of 0.0675, angle control is adjusted at 0.7 and step size of 11.0 is used. This leads to a total of 16384 triangles.

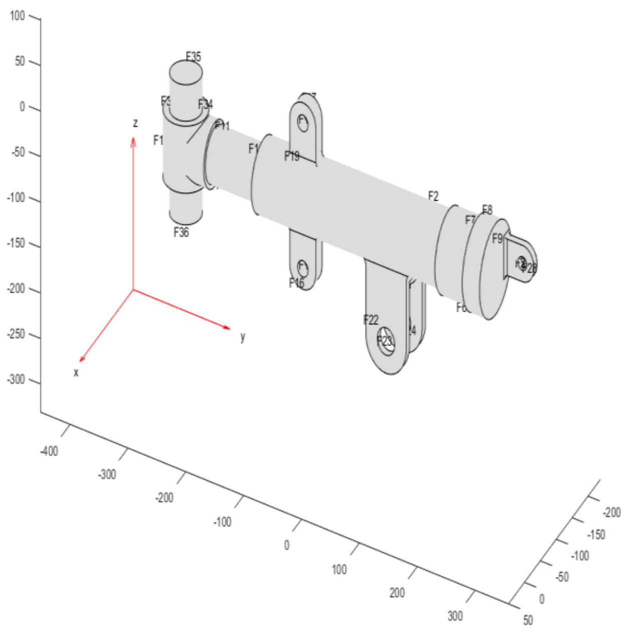

Fig. 2.Landing gear model with face labels

IV. MATERIAL PROPERTIES

The material assigned to landing gear is Ti-6Al-4V. The material specification has been provided in the Table -I.

Table -I: Property of Ti-6Al-4V

Properties	Ti-6Al-4V
Density	4.43e-6
Poisons ratio	0.342
Youngs modulus	113.8e9

Source: Matweb (Aug, 2019)

V. BOUNDARY CONDITIONS

The landing gear is installed below the fuselage and is fixed at top end thus a fix boundary condition is applied on face 29 Fig. 2.

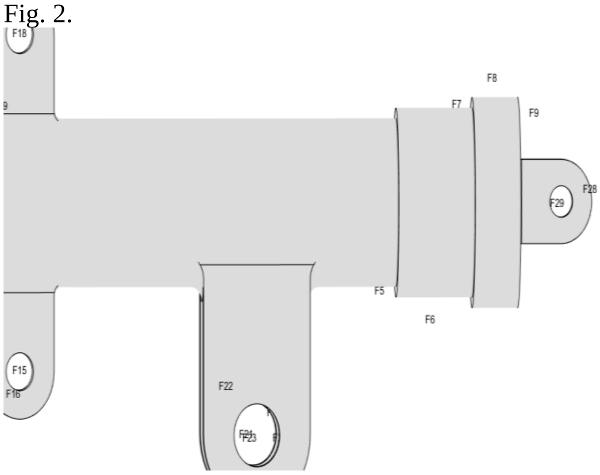

Fig. 5.Fixed support at face 29

VI. MESHING

Tetrahedral mesh is created for the landing gear. The targeted minimum element size of 7 is selected for landing gear. A total of 51933 nodes were created with a maximum element size of 27. The model is discretized into 99050 elements and quadratic geometric order is selected with mesh gradation of 1.5. The mesh quality greatly affects the accuracy of the results in finite element analysis approach.

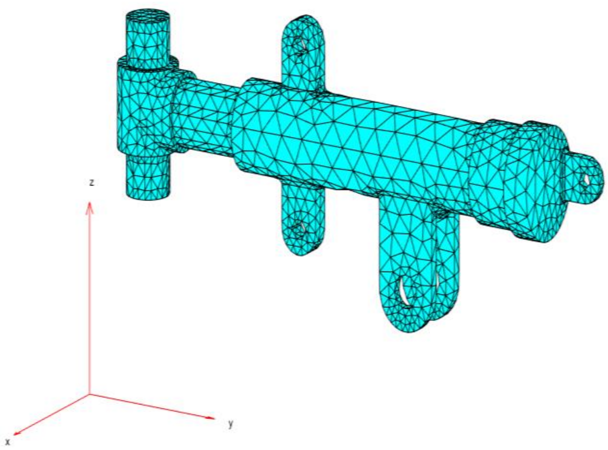

Fig. 6.Generated Mesh with minimum element size of 7

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VII. RESULT AND DISCUSSION

The vibrational characteristics of a structure (mechanical) can be understood with the help of powerful tool known as Modal Analysis. The modal analysis for the landing gear assembly is performed in MATLAB. The modal analysis results help to measure the resonance probability of landing gear and thus helps for creating a more safe structure to ensure safety of passengers by increasing the life of landing gear This analysis converts the vibrational response of a complex structure into modal parameters which are easier to analyze. The natural frequency and the mode shape of the landing gear has been find out using modal analysis in pde toolbox in MATLAB. This analysis is associated to reliability, safety and comfort. The modal parameters of landing gear have been predicted using finite element analysis. The boundary conditions have been applied that represents the way in which the structure is fixed. Then the material is assigned and finally the algorithm is applied to find the mode shape and the natural frequency. The natural frequency has been found up to a maximum of 2000Hz. After analysis two natural frequencies have been found in the range and the results are tabulated in Table -II. The natural frequency is 511.07 Hz for the first mode for the given material and boundary condition. For second mode the natural frequency is 1380.2 Hz at same end conditions. The mode shape for a system (mechanical) is the vibration pattern at a particular frequency and thus every mode has a different frequency. The knowledge of each mode of the structure helps to understand all the vibrational patterns possible.

Table -II: Result for Modal Analysis

MODE	NATURAL FREQUENCY
1	511.07
2	1380.2

VIII. CONCLUSION

The modal analysis of landing gear, designed in CREO then imported into MATLAB, has been carried out in MATLAB, to find the natural frequency, which provide accurate and faster results than ANSYS. The data of this analysis will be helpful to understand the vibrational characteristics of the landing gear. And this will help to create the structure (landing gear) which is less prone to the vibrations and if the frequency is found near to the natural frequency of the structure then the structure must be redesigned. In future the results (natural frequency) may be used to study the vibrational pattern of the landing gear. The natural frequency of the landing gear maybe find out by applying a fixed support at one end while a load at another end, which may be possible in tools other than MATLAB (pde toolbox), and the modal parameters maybe find out to study the vibrational response of the landing gear at different mode shapes.

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Rishabh Chaudhary I am a fourth year student of department of mechanical engineering in JSS Academy of Technical Education, Noida at Abdul Kalam Technical University. Area of interest includes mechanical designing, finite element analysis, simulation, material science, strength of materials, material testing. Published 2 research paper in international research journal. Certified in AutoCAD, Creo and Ansys. Currently working on research project on simulation in MATLAB. Research area includes designing of aircraft components, specifically landing gear subsystems and advancement in material and alloys for aerospace industries. Certified in AutoCAD and Creo. Presented a seminar on cryogenic heat treatment. Completed industrial training and industrial project in Creo and Ansys.