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Design and Analysis of Landing Gear

Sadaf Paikar Riyaz Ahemad Khan, MD Zikwan Ahmed, Omkar Hari Jadhav
Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, India

Abstract: *The landing gear system is of paramount importance during ground operations and take-off procedures, as it bears the brunt of the aircraft's weight and forces during these critical phases. It is evident that a significant proportion of aircraft structural failures can be attributed to landing gear malfunctions.*
During landing and take-off, the landing gear must withstand various types of loads, including side loads, compressive loads, and drag loads. Although compressive loads are predominant, the magnitudes of drag and side loads are comparatively smaller. Consequently, the landing gear is typically treated as a one-dimensional structure. Its primary function is to absorb the energy generated upon landing, thereby mitigating the impact on the aircraft frame.
For heavier aircraft, the preferred landing gear configuration is often the oleo pneumatic landing gear strut. In addition to static strength considerations, an essential criterion in its design is its ability to absorb and dissipate kinetic energy effectively during the landing process. We then take an aircraft's conventional landing gear and it is designed using CATIA and evaluated using Auto desk inventor software for structural protection. The assembly of landing gears is analysed using AUTO DESK INVENTOR tools for various composite materials and metal alloys. By importing the model landing gear into the AUTO DESK INVENTOR program, Estimation of aircraft landing gear linear stresses and deformation and analysis on main landing gear as well the nose landing gear of an aircraft by linear static structural analysis. The results of the materials listed are compared and the material with the highest factor of safety and the least value of the extreme stress generated will be regarded as the best material to prevent structural failures of the model landing gear system.

Keywords: Factor of Safety, Landing gear, Static analysis, Stress, Total Deformation

I. INTRODUCTION

Introduction to Landing Gear System

This system is one of the pivotal subsystems of the airplane and is mostly built along with the aircraft structure because of its significant influence on the airplane's structural nature. The function of the landing gear of the airline is to provide during taxi, take-off, and landing operations, a suspension mechanism. The kinetic energy of the landing impact is consumed and dispelled, thus reducing the impact loads transmitted to the airframe.

An aircraft has two landing gears: the Nose Landing Gear and the Main Landing Gear. Not only is the nose wheel necessary for a safe landing, but it is also required for aircraft steering while taxiing on the ground. The main landing gear is aimed at allowing the aircraft to land safely. Both of these landing gears work to make jerk-free landings.

Airplane undercarriage bears the entire weight of an aircraft throughout taxiing and landing operations. These gear systems are connected to the aircraft’s key structural components.

We can subdivide landing gear as:

- Wheels to allow the operation on airport runways, to and from them, and other hard surfaces.
- Skids were found on Choppers, hot air balloons, and some tail dragger aircraft in the tail area.

Shock-absorbing equipment, fairings, controls, retraction mechanisms, cowling, warning systems, brakes, and structural members required to mount the gear to the aircraft are considered to be part of the undercarriage, regardless of the type used.

To authenticate structural robustness and structural design loads, it is necessary to compute the loads acting on the landing gears in-flight tests. The terrain load calibration test usually entails separating the landing gears from the test aircraft, then mounting it on a specifically designed test rig and applying required loads on the landing wheel system.

Thus, it is not possible to fully simulate the stiffness of the relation between the landing wheel and the rig as the real stiffness of the connection with the aircraft. This will influence the efficiency of load calculation data.

Horack suggested studying the layout overhanding gear. Landing gear fatigue test technology, load association of repeated loading, and state of service load. The application of lightweight materials was suggested by Yangchen

Generally, the following are the parameters of the landing wheel system to be ascertained:

1. Type of Gear
2. Fixed, retractable, or partly retractable.
3. Wheel track.
4. Height.
5. Wheelbase.
6. Dia of Strut.
7. The distance between the main wheel and point of balance of aircraft.
8. Sizing of the tire (diameter, width)

Fig 1: Landing Gear System

II. REVIEW OF LITERATURE

The following section of the report addresses some of the research works carried out by various researchers concerning Landing Gear Systems, which aided us in getting the required information to carry out our project.

Design and Analysis of Landing Gear for Commercial Airplane [1]:

Sk Sariful Islam's landing gear function is the most significant structural unit of an all-type aircraft that carries out the entire body safely on the ground during takeoff and landing. Depending on the configuration and size of the aircraft, several types of landing gear are used. With one front or nose landing gear unit and two primary landing gear systems, tri- cycle configurations are commonly used. Absorbing or dissipating energy is the primary feature of all types of shock absorbers. It reduces the impact of flying over the ground for a commercial aircraft, contributing to improved ride quality and increased comfort due to reduced disturbance amplitude. The most significant bouncing mechanism in the landing gear is repeated over and over, each time with a little less, until the up-and-down movement stops entirely. A single and dual shock absorber landing gear is modeled in this paper and a 3D model is obtained using CATIA v5, and AUTO DESK INVENTOR v12 is analyzed. Two types of shock observers(signal and dual) are compared to verify the best shock absorber.

Design and Analysis Aircraft Nose and Nose Landing Gear [2]:

Rajesh A, Abhay B T work on Tri-cycle arrangement landing gear is commonly used as it is simple; both structurally as well as aerodynamically convenient. It has its drawbacks, but it is preferable over other configurations. Factors such as its weight drag, sudden load application, acoustics, fatigueless. appear to slow down its life and efficiency. Among main landing gear and nose landing gear; the former carries about 85% of the total weight of aircraft and the latter carries around 12-15% of the weight. In contrast to the main landing gear, the nose landing gear is also a source of noise and its influence is prominent. The executive jet aircraft are extensively investigated in this project and a nose landing gear similar to those of executive jets is modeled using CATIA. The same geometry is imported into AUTO DESK INVENTOR ICEM and different angles of attack are evaluated for body flow.

Pressure variation, temperature, density, and velocity distribution are noted across the body and then the Lift and Drag coefficient is plotted for results obtained against the angle of attack. Checking the strength and stiffness of the built landing gear is also important .Therefore, the static structural and impact test for built geometry has been carried out using AUTO DESK INVENTOR APDL and Explicit. For two different materials, such as steel and aluminum alloy, stress distribution and deformation were noted and primary acoustic results were compared with the available data.

LANDING GEAR OF AN AIRCRAFT [3]:

Durga Kumari and Love Sharma work on Landing gear in an aircraft's undercarriage. An airplane's landing gear is equipment that performs two primary purposes. First, it helps aircraft to land safely and successfully, and second, it supports aircraft in a restful state. The landing gear is constructed according to the aircraft's specifications and the essence of its function. An airplane's landing gear is equipment that performs two primary purposes. First, it helps aircraft to land safely and successfully, and second, it supports aircraft in a restful state. The landing gear is constructed according to the aircraft's specifications and the essence of its function. In this project, we will first study all the functional specifications and landing gear components that can affect an aircraft's purpose. It has been evident from the above work that the landing gear can be designed and modeled according to requirements using PRO-E. On a Pro/E assembly, we can perform integrated simulation and it is possible to generate an automatically meshed model containing very small sections. From the above analysis, early insight into its performance can be obtained and a concept model can be analyzed to obtain accurate stresses and displacements automatically. On this basis, by adjusting relevant parameters and materials, one can optimize the design. In this way, for a higher performance, one can design a landing gear to suit the purpose. There have been several challenges for landing gear designers and practitioners with the need to design landing gear with minimal weight, minimum volume, high performance, improved life, and reduced life cycle costs . In configuration design, use of materials, design and research processes, and the potential design of landing gear for aircraft faces several new challenges.

Design and Structural Analysis of Main Landing Gear for Lockheed T-33 Jet Trainer Aircraft [4]:

Monisha M and Pooja S work focuses primarily on the structural design and study of a jet trainer aircraft's main landing gear, which is economical and has a high strength-to-weight ratio, but is still simple in design. An effort is made to synthesize graphically and comprehend the mechanism’s kinematics.

ADAMS is used to check the design's mobility. In Unigraphics NX 10, computer 3D modeling of the assembly is carried out and finite element analysis is performed to analyze stresses produced at the rate of descent during landing. The linear static analysis is done with the aid of the AUTO DESK INVENTOR Workbench finite element software to measure the deflections of the main landing gear and to estimate the internal stresses. In this study, the simulation findings are discussed.

A subsonic American jet trainer aircraft has been designed to reflect the primary geometry of the main Lockheed T-33 Shooting Star (or T-Bird) landing gear. ADAMS software serves the task of recognizing the mechanism's basic skeleton ,which never the less embodies the dimensions of the model and defines the motion direction in real-time. The deflected structure of the landing gear in its maximally loaded state was shown by AUTO DESK INVENTOR Workbench, the finite element software. The graphical pictorial outputs displayed varying stress levels corresponding to the gear geometry. Here, it is evident that 118.66 MPa is the maximum stress level, which is less than the permissible yield power. It can be interpreted from the design stress measurement that the acceptable stress is 197.5 MPa and the design stress is 131.6 MPa, and the maximum stress from the numerical computation in the workbench is 118.66 MPa, so we can infer that the structure is secure and meets the landing criteria set by Lockheed T-33 aircraft.

Design and Linear Static Analysis of Landing Gear [5]:

Muhammed Faizal Elayancheri work on Landing is one of the most common aircraft maneuvers. Because of its complex behavior, the landing gear is called a nonlinear structure. Significant amounts of impact forces are passed into the nose gear and main landing gear during the landing process. The main objective of this paper is to present an aircraft landing gear prototype using CATIA V5 software to research landing gear actions according to actual working conditions.

Static loads are applied over the landing gear and internal forces are derived from key components of the landing gear, such as the separate study of the torque arm for the internal forces collected from the generalized modal, modeled with CATIA V5, and imported to MSC Patran. As a solver, MSC Nastran is used. Linear static analysis was performed from the obtained limit stresses to identify the stress of the main landing gear under different conditions.

DESIGN AND ANALYSIS OF AIRCRAFT LANDING GEAR USING DIFFERENT ALLOYS [6]:

Dr. V. Jaya Prasad, P. Sandeep Kumar Reddy,
B. Rajesh, and T. Sridhar

The purpose of this study was to examine the structural analysis of landing gear for various materials. The research explores the most appropriate material for the construction of the landing gear by analyzing the stress and deformation produced due to loading conditions.

Analysis of stress plays an important role in finding structural protection and assembly integrity. The previous stress calculation helps to find suitable material and geometrical dimensions.

Modal Analysis of a typical Landing Gear Oleo Strut [7]:

Dr. N Sreenivasa Babu Structural analysis to analyze the deformation and Von mises stress levels and analysis of vibration measuring frequency levels under various conditions. In comparison, for take-off and landing conditions, various materials are examined and frequency levels at different loading conditions are compared. In the nodal analysis for various materials, the frequencies are evaluated. The frequency is 23.6339 Hz for the Ti 6Al-4V material oleo strut and the difference is not noticeable during take-off and landing. The results for displacement are 0.36 mm from the static study and Von mises Stress is 97.35 for Ferrium S53 material and is ideally suited and sustainable both for landing and take-off.

2.1 Research Gap

- The complete load of the airplane has to be borne by the landing gear system and due to this, it has to be very powerful. This is why landing gear is made of steel because of its robust nature but it is not used in other parts of aircraft since it is heavy. Titanium alloys are also used in the parts of a landing gear.
- Our project aims at the explicit fundamental analysis of aircraft landing wheels for discrete alloys and composite materials.

2.2 Objective

- Following are the objectives of this project:
- Estimation of air craft landing gear linear stresses and deformation by linear static structuralanalysis.
- Perform static structural analysis on main landing gear as well the nose landing gear of an aircraft.
- Design the air craft landing gear using different materials and alloys and analyze them and determine the best material to be used.
- Evaluation of the Factor of Safety for the air craft landing equipment using different materials.

2.3 PROBLEM IDEFINITION

- Quite high loads impact the landing gear during landing. It is due to the weight of the aircraft and its rate of descent as well as forward speed during touchdown. If the load on the landing gear reaches the threshold value, the landing wheel will be damaged or destroyed.
- The landing wheel system should be adequately impervious to all presumed loads, however, the measurements taken should not be bulky, because it has to protect other airship structure parts from being damaged.

III. METHODOLOGY

3.1 Methodology Overview

The below flowchart shows the order of the steps to be followed to meet our project requirements

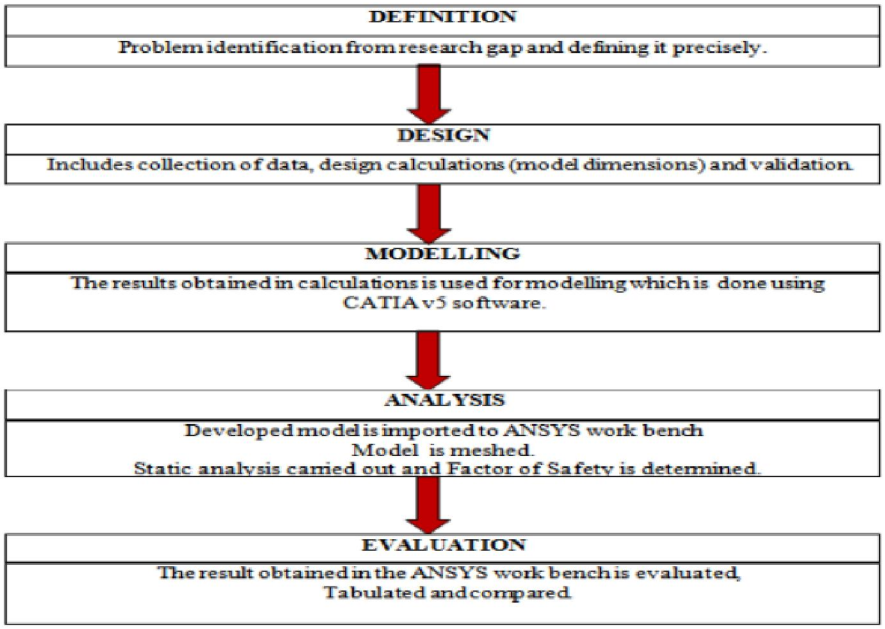
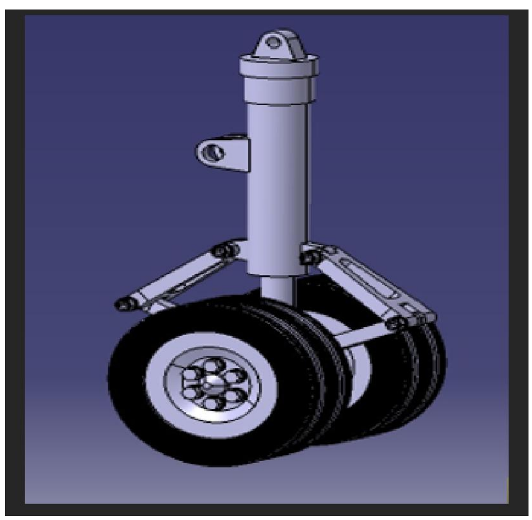


Fig 3: Methodology chart

IV. MODELLING

Landing Gear



V. CONCLUSION

Based on the conclusions drawn from the reference papers attached we were able to narrow down the two best metal materials to be used as the base material for the strut i.e. Aluminum 7075 and Titanium 10Al-2Fe-3V.An attempt was made to use CFRC- Carbon Fiber-Reinforced Carbon as the base material of strut.

Landing gear materials commonly must have good fracture toughness, High static strength, and fatigue strength, seen in metals and alloys like steel, aluminum, and titanium.

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