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Design and Strength Analysis of Nose Landing Gear

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ABSTRACT:

During the conceptual design phase of aircraft the integration of undercarriage system is very important and it is often difficult to achieve on the first time. The nose wheel landing gear preferred configurations for light naval trainer aircraft. The main objective of this project is to improve the static strength criteria and fatigue life of Nose Landing Gear Barrel considered. The investigations includes preliminary design layout for Nose Landing Gear Barrel and initial sizing has been done. It has been designed and evaluated for strength criteria. A method of analysis for the design of Nose Landing Gear Barrel made up of Al-Ti alloy (Ti-6Al-4V) with static loads of axial, bending and normal loads are applied. The geometric modeling of the Nose Landing Gear Barrel was carried out using CAD package CATIA V5 R20 and pre and post processing was done through ANSYS workbench version 14.5. The stresses and displacements are obtained as the final results in the post processing part of finite element software.

INTRODUCTION:

Landing gear is the undercarriage of an aircraft or spacecraft and is often referred to as such. For aircraft, the landing gear supports the craft when it is not flying, allowing it to take off, land and usually to taxi without damage. Wheels are typically used but skids, skis, floats or a combination of these and other elements can be deployed depending both on the surface and on whether the craft only operates vertically (VTOL) or is able to taxi along the surface. Faster aircraft usually have retractable undercarriage, which folds away during flight to reduce air resistance or drag.

For launch vehicles and spacecraft Landers, the landing gear is typically designed to support the vehicle only post-flight, and are not used for takeoff or surface movement. The nose landing gear (NLG) is hydraulically extended in the aft direction and mechanically locked in the down position. The NLG is hydraulically retracted in the forward direction and mechanically locked in the up position. In general, the followings are the landing gear parameters which are to be determined in this chapter:

1. Type (e.g. nose gear (tricycle), tail gear, bicycle)
2. Fixed (faired, or un-faired), or retractable, partially retractable
3. Height
4. Wheel base
5. Wheel track
6. The distance between main gear and aircraft cg
7. Strut diameter
8. Tire sizing (diameter, width)
9. Landing gear compartment if retracted

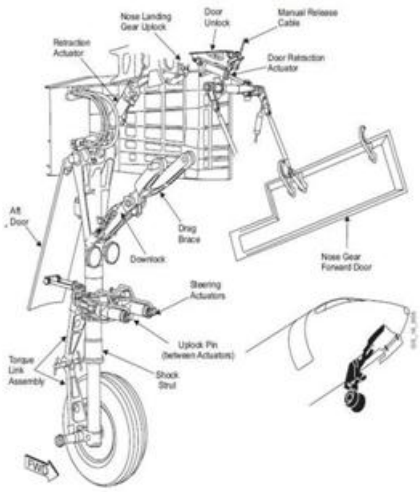

Figure: Nose Landing Gear

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The nose gear bay is completely enclosed by an aft door, mechanically linked to the nose gear, and by two hydraulically-actuated forward doors. During normal operation, the forward doors open only during gear retraction and extension (transit) operation. The forward doors can be manually opened by the manual release system and can be opened for ground maintenance operation when required. The aft door is mechanically linked to the nose gear and positioned to the open and closed position with each main gear operation.

LANDING GEAR TYPES:

The type of gear depends on the aircraft design and its intended use. Most landing gear has wheels to facilitate operation to and from hard surfaces, such as airport runways. Other gear feature skids for this purpose, such as those found on helicopters, balloon gondolas, and in the tail area of some tail dragger aircraft.

Basic landing gear types include those with

A. Wheels
B. Skids
C. Skis
D. floats or pontoons

Fig: Landing Gear Types

GEOMETRY:

Wheel Base:

Wheel base (B) plays an impo rtant role on the load distribution between primary (i.e. main) gear and secondary (e.g. nose, or ta il) gear. This parameter also influences the gro und controllability and ground stability. Thus, th e wheel base must be carefully determined and a n optimum value needs to be calculated to ensure it meets all relevant design requirements. In this section, the load distribution between main and nose gear is examined. The effect of wheel base on the ground controllability and ground sta bility will be discussed in the subsequent section s.

Figure shows a stationary aircraft with a tricycle landing gear on the ground. The aircraft weight (W) is carried by three wheels (i.e. two main and one nose gear). Due to the ground mobility (i.e. steering) requirement, typicall y the nose gear must not carry less than about 5 percent of the total load and also must not carry m ore than about 20 percent of the total load (e.g. aircraft weight). Thus, main gear carries about 80% to 95% of the aircraft load. Therefore nose wheel could be much smaller than the main w heels. This is true for the comparison between n ose strut and main struts. The loads on nose and main gears are denoted by Fn and Fm respective ly. These data are employed in early preliminary design of landing gear.

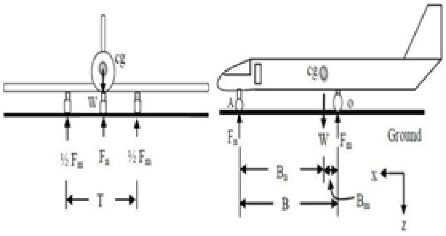

Fig: Wheel Load Geometry

Calculation of the static loads o n each gear is performed by employing equilibrium equations. Since the aircraft is in static equilibri um, the summation of all forces in z direction must be zero:

$$\Sigma F_z = 0 \Rightarrow F_n + F_m = W$$

Furthermore, the summation of all moments about o is zero:

$$\Sigma M_o = 0 \Rightarrow F_n B - W B_m = 0$$

Thus the percentage of the static load (i.e. aircraft weight) which is carried by the nose gear is:

$$F_n = \frac{B_m}{B} W$$

In addition, the percentage of t he static load which is carried by the main gear is

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$$F_m = \frac{B_n}{B} W$$

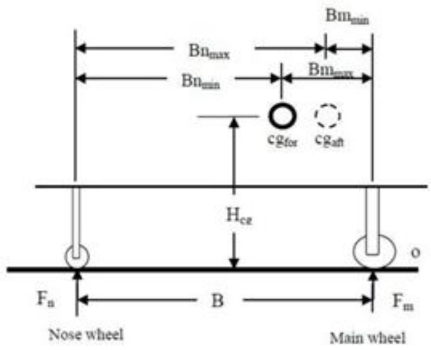

Fig: Wheel Load Geometry

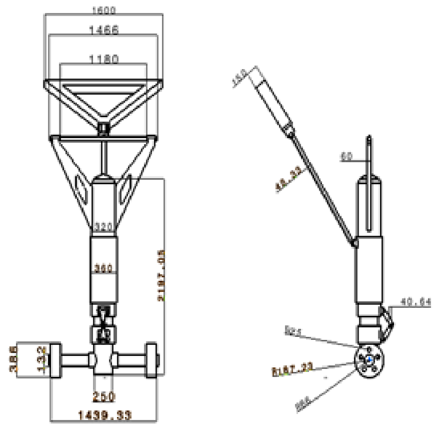

Fig: 2D drafting of nose landing gear

The above-mentioned relationships are applicable only in static situations. There are two other interesting conditions that cause landing gear to experience different loadings:

1. change in the aircraft center of gravity location;
2. dynamic loading.

Due to the possibility of a change in the load distribution, or having different com binations of cargo, or number of passengers, the geears must carry a load other than the nominal stati c load. In the x-axis, an aircraft center of gravity is allowed to move between two extreme limits: a. most aft location (Xcgaft), and b. most forward lo cation (Xcgfor).

MATERIALS USED:

The material selection is the most important factor while designing a component. It offers a major role in assigning the strength to the part as we can tailor the material itself to suit the design requirements.

The main materials used in nose landing gear are titanium, aluminum, steel and their alloys. The general properties of these materials are:

1. Aluminum alloy

Density: 2.77g/cc Young's modulus: 71 GPa Poisson's ratio: 0.33

2. Stainless Steel

Density: 7.75g/cc
Young's modulus: 134 GPa
Poisson's ratio: 0.31

3. Titanium Alloy

Density: 4.620g/cc
Young's modulus: 96 GPa
Poisson's ratio: 0.39

4. Carbon fiber

Density: 1.42g/cc
Young's modulus: 134 GPa
Poisson's ratio: 0.2

RESULTS:

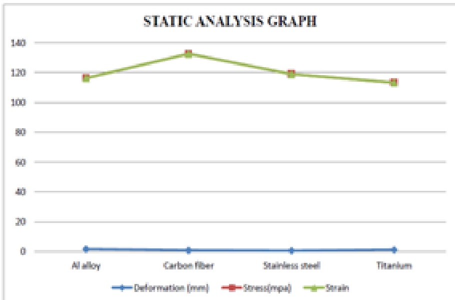

Fig: Static Analysis Graph

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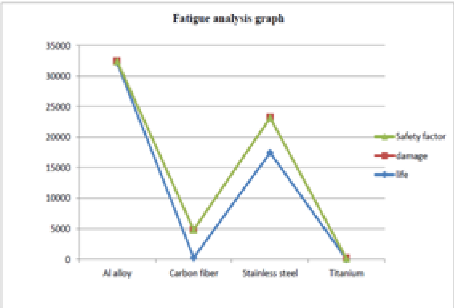

Fig: Fatigue Analysis Graph

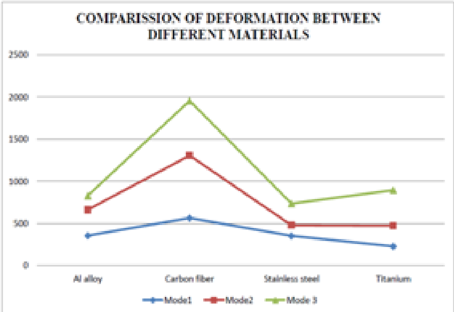

Fig: Comparisons of Deformation between Different Materials

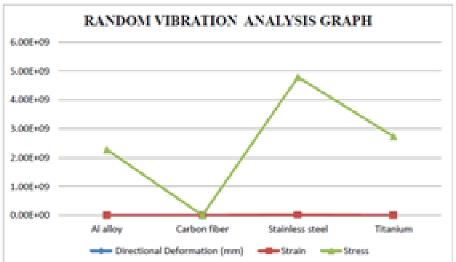

Fig: Random Vibration Analysis Graph

CONCLUSION:

- Static Analysis, Modal Analysis, Random Vibration Analysis and Fatigue analysis are done on the landing gear by varying aterials Aluminum alloy, Stainless Steel, Titanium alloy and Carbon Fiber.
- By observing static analysis results, the stress values are less than the allowable stress values for all materials. So using composite material Carbon Fiber is safe under working conditions.
- By observing fatigue analysis results, the life of the landing gear is less for Carbon Fiber, the damage factor is more for tainless Steel (i.e.) the landing gear fails when the load applied 5733.5 times the present load, for Carbon Fiber it is 4581 times the present load.
- By observing modal analysis results, the deformation and frequency values are more when
- Carbon Fiber is used. By increasing the frequencies, the vibrations will increase.
- By observing Random vibration analysis results, the stress and directional deformation values are less when Carbon Fiber is used.
- Theoretical calculations are done. By comparing the results between omputational and analytical results, the deformation and stress values are almost similar with each other.
- Hence by observing the results and validation by using the composite materials of carbon fiber the weight of the nose landing gear barrel can be minimized so the safety factor and the life will be increased.
- Future research can be implemented from this thesis, by incorporating the appropriate
- properties and different composites of carbon fiber and by varying the thermal loads.

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