DESIGN OPTIMIZATION AND ANALYSIS OF AIRCRAFT LANDING GEAR

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Abstract: *Landing Gear is a vital structural unit of an aircraft which enables to take off and land safely on the ground. A variety of landing gear arrangements are used depending on the type and size of an aircraft. Even during a normal landing operation heavy loads are to be absorbed by the landing gear. In turn joints are to be provided such that such heavy concentrated loads are first received by the airframe and subsequently diffused to the surrounding areas. Normally heavy concentrated loads are received through a lug joint. Therefore design of a lug joint against failure under static and fatigue loading conditions assumes importance in the development of an aircraft structure. This project deals with the design and analysis of a typical lug joint representative of a landing gear attachment of a small airplane. The design will provide safety against failure of the lug and failure of the pin in Catia. A typical landing load case will be assumed for which structural analysis will be carried out. During landing, there will be three different types of loads like Vertical load, Drag load, and Side load. As a first approximation the landing gear space structure will be idealized as a statically determinate structure and a stress analysis will be performed using strength of material approach. The stresses developed because of loads on the structural members of the landing gear will be calculated. A finite element model of the landing gear structure will be developed and analyzed in Ansys. The FEA stress and deformation results will be compared. These stresses and internal loads can then be used for the design of various structural members of the landing gear unit. Fatigue life to crack initiation will be estimated for a critical lug of the landing gear unit by considering the constant amplitude landing cycles.*

I - INTRODUCTION

Aircraft landing gear supports the entire weight of an aircraft during landing and ground operations. They are attached to primary structural members of the aircraft. 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. Aircraft that operate to and from frozen lakes and snowy areas may be equipped with landing gear that have skis. Aircraft that operate to and from the surface of water have pontoon-type landing gear. Regardless of the type of landing gear utilized, shock absorbing equipment, brakes, retraction mechanisms, controls, warning devices, cowling, fairings, and structural members necessary to attach the gear to the aircraft are considered parts of the landing gear system.

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Numerous configurations of landing gear types can be found. Additionally, combinations of two types of gear are common. Amphibious aircraft are designed with gear that allows landings to be made on water or dry land. The gear features pontoons for water landing with extendable wheels for landings on hard surfaces. A similar system is used to allow the use of skis and wheels on aircraft that operate on both slippery, frozen surfaces and dry runways. Typically, the skis are retractable to allow use of the wheels when needed.

Landing Gear Arrangement

Three basic arrangements of landing gear are used: tail wheel type landing gear (also known as conventional gear), tandem landing gear, and tricycle-type landing gear.

Fig: Landing Gear Arrangement

II - LITERATURE SURVEY

Design Optimization Of Landing Gear Of An Aircraft - Landing gear of an aircraft is an equipment that serves two primary functions. First, it allows aircraft to safely and successfully land and second is to support aircraft at rest condition. Landing gear is designed according to requirement and nature of work of aircraft. In this project, we will first study all functional specifications and parts of landing gear which can affect purpose an aircraft. Some of these parts to be consider are: 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. In this project work, we will optimize design of landing gear by considering different material properties, loading conditions and dimension optimization with different landing conditions during operation. For modeling of landing gear we will use CREO element/pro 5.0 version of PROE. After this, we will perform structural analysis, dynamic mechanism analysis and fatigue analysis and compare results using ANSYS-11.0.We will also try to validate the results with available research papers and manufacture’s specification.

From above work, it has been clear that the landing gear can be design and modeled using PRO-E as per requirements. We can perform integrated simulation on a Pro/E assembly and automatically meshed model can be generated containing very small sections. From above analysis, one can get early insight as to its performance and can analyze a concept model to automatically obtain accurate stresses and displacements. On this basis one can optimize the design by changing relevant parameters and material. In this way, one can design a landing gear for a greater performance to suit for the purpose.

Landing Gear of an Aircraft Structure: A Review; the landing gear system of an aircraft is a system. It also absorbs the energy from the impact of landing Numerical type simulation has become highly invaluable tool for the assessment of the landing gear type dynamics also as well as of aircraft landing structure gear interaction. This paper also describes the normal structure review of a simple landing-gear structure model system, and which is accurately simulates with the energy system absorbed by the gear without the adding substantial structure and complexity with the model. it carries the structure aircraft weight at all require ground operations, including, landing, take off, taxiing, and towing. In future we know that advances in computational type speed have made aircraft and high spacecraft crash simulations design using an explicit, transient type dynamic, finite element analysis (FEM) code are the more feasible. For a plane crash model type system the landing gear is also exact response is approximated work with a many strong spring where many different force applied to the different fuselage. And it is also computed in a user written works type. Helicopter crash type simulations which is using this approach that are compared with different necessary data is also acquired with the experimental method and data from a full structure crash structure test can be achieved by with the use of an aircraft of a composite. Depends on type of landing gear systems is also presented. Specifically, a nonlinear type model can easily developed which is simulated, and against static and dynamic data test data. Many nonlinear structure effects such as a velocity type squared related high damping, poly tropic gas law, stick-slip friction, a geometry governed with the high model structure for the high discharge type coefficients and methods, effects a nonlinear spring and damping model structure

Design and Analysis of Landing Gear Lug attachment in an Airframe; Landing gear is a vital structural unit of an aircraft which enables to take off and land safely on the ground. A variety of landing gear arrangements are used depending on the type and size of an aircraft. The most common type is the tri-cycle arrangement with one nose landing gear unit and two main landing gear units. Even during a normal landing operation heavy loads (equal to the weight of an aircraft) are to be absorbed by the landing gear. In turn joints are to be provided such that such heavy concentrated loads are first received by the airframe and subsequently diffused to the surrounding areas. Normally heavy concentrated loads are received through a lug joint. Therefore design of a lug joint against failure under static and fatigue loading conditions assumes importance in the development of an aircraft structure. This project deals with the design and analysis of a typical lug joint representative of a landing gear attachment of a small transport airplane. The design will provide safety against 1) failure of the lug, 2) failure of the pin. The types of loadings to be considered are a) axial, b) transverse or drag load. Aircraft design practices will be used. A FEA will be carried out to compare the design calculations and to determine the stress concentration factor in order to estimate the maximum local tensile stress which will be required in the fatigue analysis of the lug joint. Fatigue life to crack initiation at the high stress location will be estimated by using Miner's rule.

III - OBJECTIVES AND METHODOLOGY

The objective of this project work is to successfully develop a design of an Aircraft Landing Gear. The mechanism is to be reliable, simple, cost-effective and practically feasible. The aim of this Landing Gear mechanism is to provide Baring conditions to the aircraft on runways, so as to enable added threshold speed on curves in comparison with non stresses. This system is also supposed to enhance aircraft and passenger comfort as the side force felt during landing taking on the runway comparatively more or less.

The methodology adopted to use standard and presently used components in design rather than to design all components from ground up. The advantage of this method is that, you do not have to spend ridiculous amount and time in testing the integrity of each part as they have already proved their worth in real world applications.

Initially the design was adopted from an existing landing gear and minor changes were made to suite our purpose, the landing mechanism first devised was based on using driven by engine for lifting and lowering mechanism. This mechanism was later dropped in testing phase due to following disadvantages.

1. It had a very large response time; this was not suitable for a landing gear approaching curve at a very high speed.

2. Wear and tear of wheels and contact nut bearing is too high to be satisfactorily used in a landing gear.

Due to these disadvantages, the hydraulic system design was dropped and a fully new design was defined. The design also uses the same landing gear mechanism setup. The software to be used in design is Catia V5 and testing of design is Ansys.

Summary of capabilities

Catia Elements is a software application within the CAID/CAD/CAM/CAE category, along with other similar products currently on the market.

Engineering Design

Catia Elements offers a range of tools to enable the generation of a complete digital representation of the product being designed. In addition to the general geometry tools there is also the ability to generate geometry of other integrated design disciplines such as industrial and standard pipe work and complete wiring definitions. Tools are also available to support collaborative development.

Analysis

Ansys Elements has numerous analysis tools available and covers thermal, static, dynamic and fatigue FEA analysis along with other tools all designed to help with the development of the product. These tools include human factors, manufacturing tolerance, mould flow and design optimization. The design optimization can be used at a geometry level to obtain the optimum design dimensions and in conjunction with the FEA analysis.

IV - WORKING METHODOLOGY

Landing gear is the undercarriage of an aircraft or spacecraft and may be used for either takeoff or landing. For aircraft it is generally both. It was also formerly called alighting gear.

For aircraft, the landing gear supports the craft when it is not flying, allowing it to take off, land, and 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 undercarriages, which fold 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 is typically not used for takeoff or surface movement.

Aircraft landing gear usually includes wheels equipped with simple shock absorbers, or more advanced air/oil oleo struts, for runway and rough terrain landing. Some aircraft are equipped with skis for snow or floats for water, and/or skids or pontoons

Wheeled undercarriages normally come in two types:

- Conventional or "tail dragger" undercarriage, where there are two main wheels towards the front of the aircraft and a single, much smaller, wheel or skid at the rear
- Tri cycle undercarriage where there are two main wheels (or wheel assemblies) under the wings and a third smaller wheel in the nose

2D Drawing of Aircraft Land Gear Components

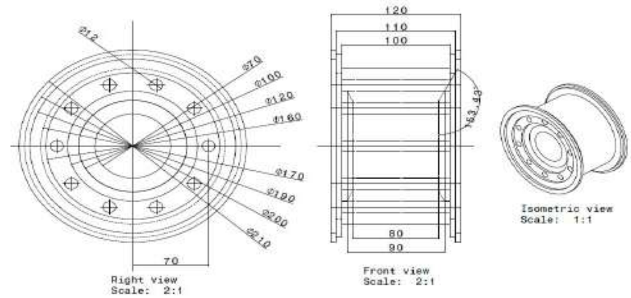

Fig: Rim

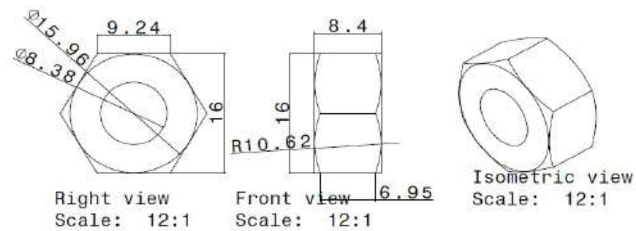

Fig: Hexagonal Nut (M12)

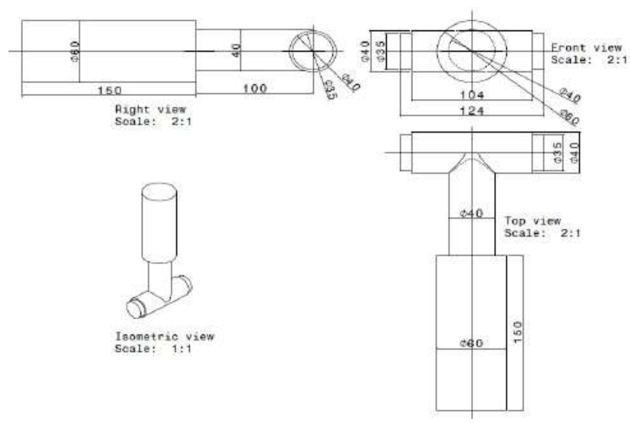

Fig: Suspension Support

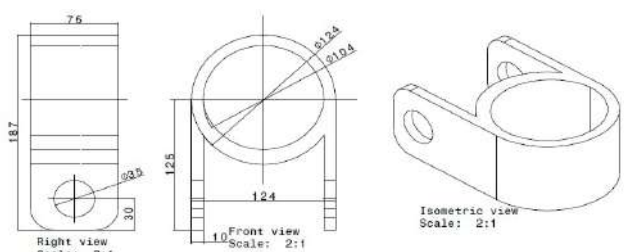

Fig: Suspension Clamp

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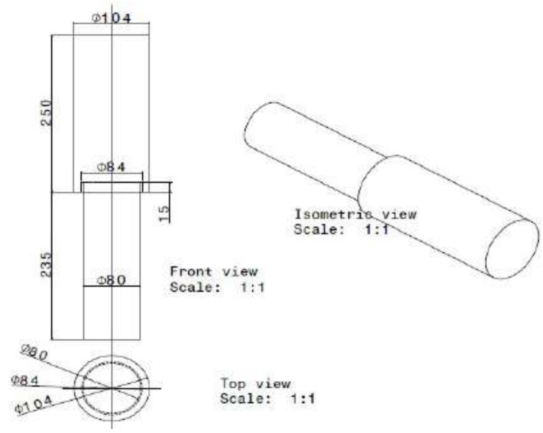

Fig: Suspension System

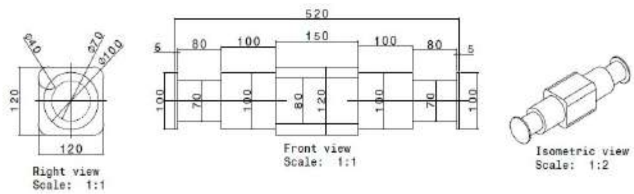

Fig: Working Axle

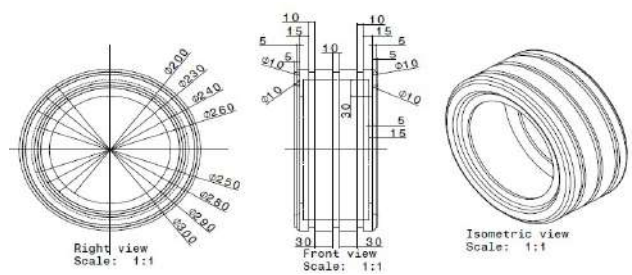

Fig: Wheel

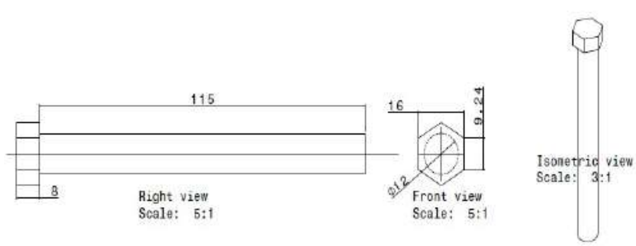

Fig: Hexagonal Bolt (M12x115)

V - DESIGN METHODLOGY OF AIRCRAFT LANDING GEAR

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle

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management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics).

Modeling of Aircraft Landing Gear In Catia V5

This Aircraft Landing Gear is designed using Catia v5 software. This software used in automobile, aerospace, consumer goods, heavy engineering etc. it is very powerful software for designing complicated 3d models, applications of CATIA Version 5 like part design, assembly design.

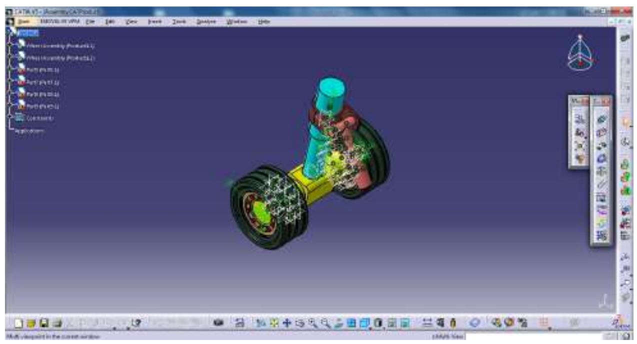

Fig: Model design in CATIA-V5

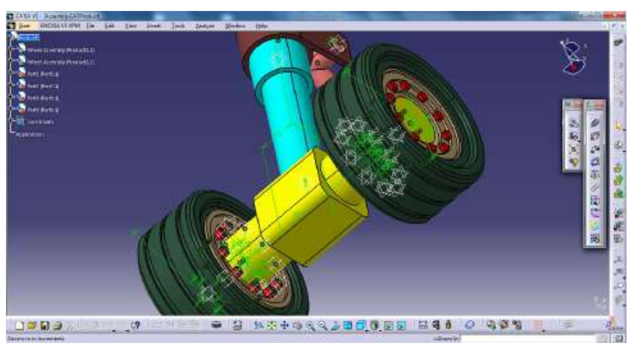

Fig: Model arrangement in CATIA-V5

VI - ANALYSIS OF AIRCRAFT LANDING GEAR

Preprocessor

In this stage the following steps were executed:

- **Import file in ANSYS window**

  File Menu > Import> STEP > Click ok for the popped up dialog box > Click Browse" and choose the file saved from CATIAV5R20 > Click ok to import the file

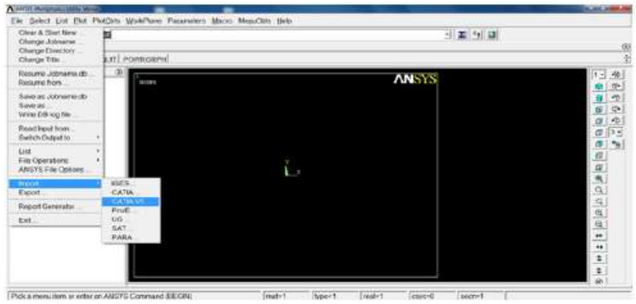

Fig: Import panel in Ansys.

VII - DISCUSSION ON ANALYSIS RESULT

Results of Displacement analysis:

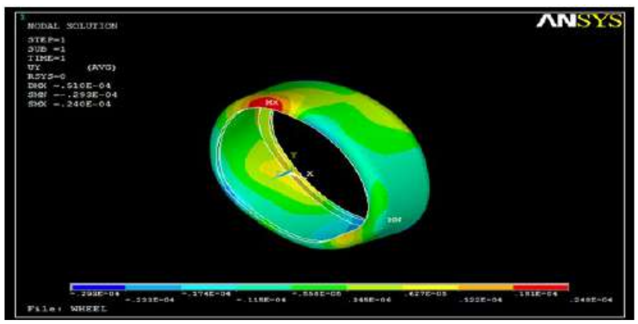

Fig: Wheel Displacement

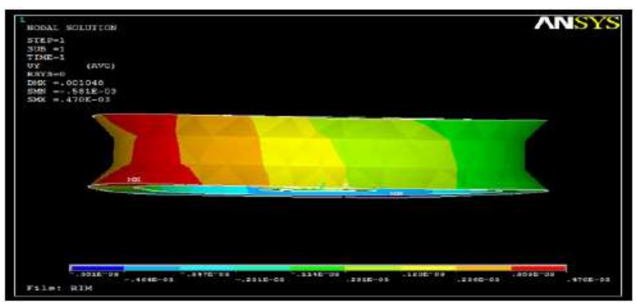

Fig: Rim Displacement

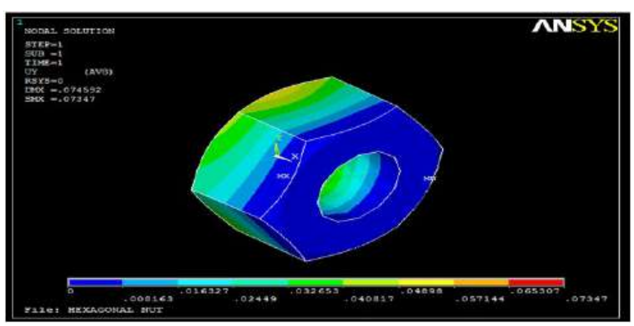

Fig: Hexagonal Nut Displacement

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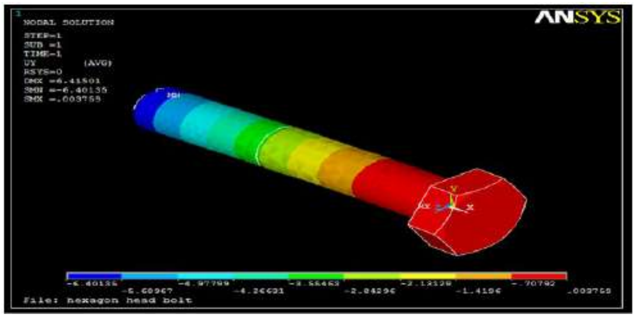

Fig: Hexagonal Bolt Displacement

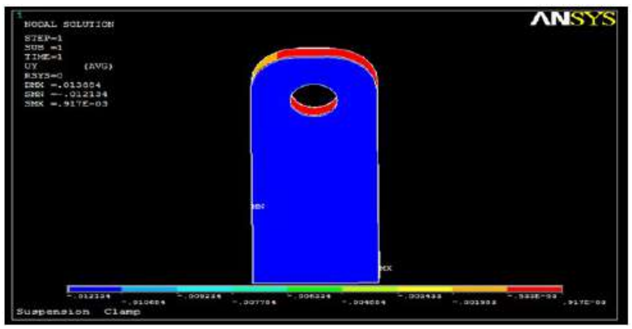

Fig: Suspension Clamp Displacement

Results of Stress analysis:

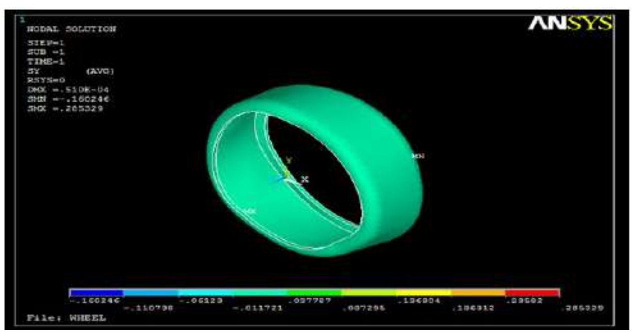

Fig: Wheel Stress

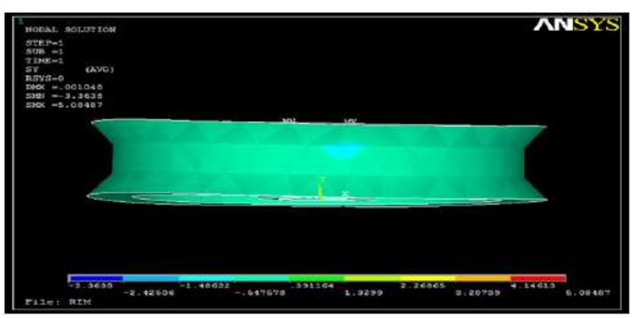

Fig: Rim Stress

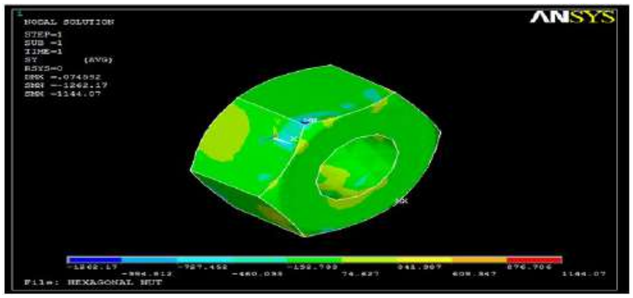

Fig: Hexagonal Nut Stress

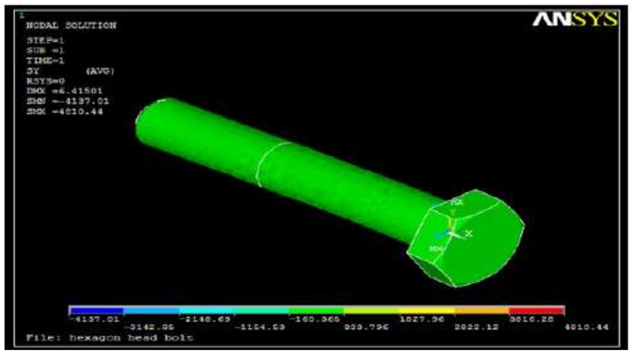

Fig: Hexagonal Bolt Stress

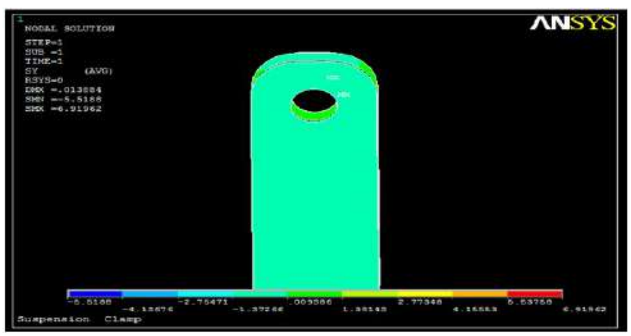

Fig: Suspension Clamp Stress

Results of Strain analysis:

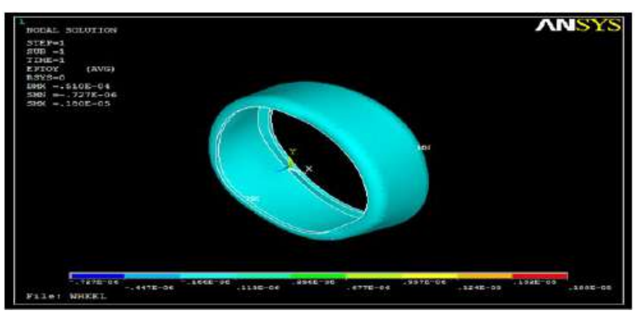

Fig: Wheel Strain

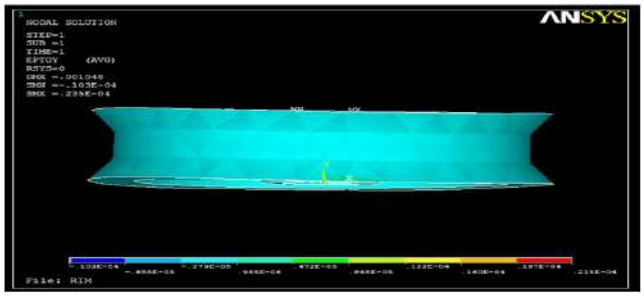

Fig: Rim Strain

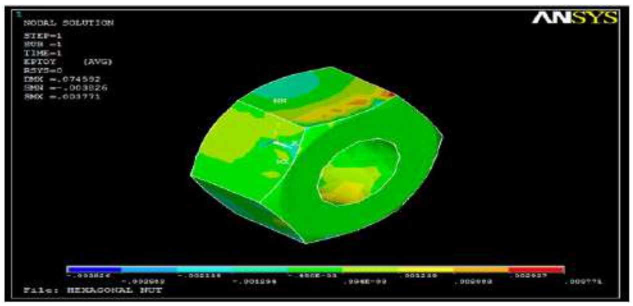

Fig: Hexagonal Nut Strain

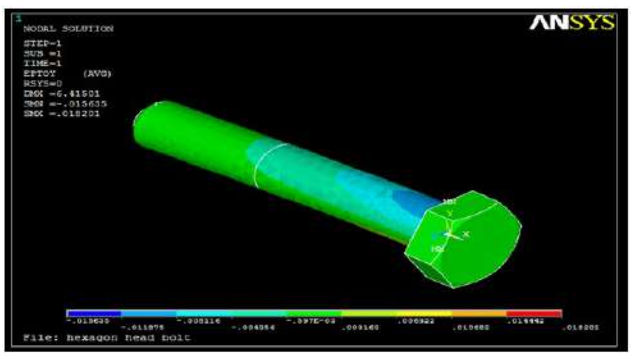

Fig.7.14: Hexagonal Bolt Strain

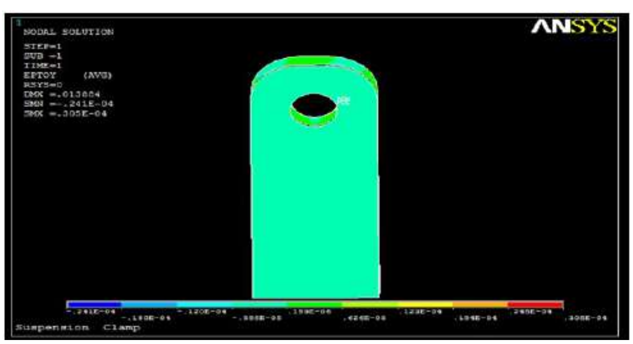

Fig: Suspension Clamp Strain

VIII - CONCLUSION

The project "Aircraft Landing Gear" has been successfully designed and tested. Presence of every module has been reasoned out and designed and analyzed carefully thus contributing to the best working of the unit. Secondly, the trend towards low power hand held transceivers increases all of these challenges. Keeping all the above parameters in view we have designed a low cost integrated system for monitoring the different types of parameters between systems.

As shown above figures, the displacement of the design is meshed and solved using Ansys and displacement, which is very less. This is showing us that clearly each component in assembly is having minor displacement. Stress is at the fixing location (Minimum Stress which is acceptable), stress value. The value which is very less compared to yield value of Aluminum; this is below the yield point. The maximum stress is coming, this solution solving with the help of Ansys software so that the maximum stress is less .so we can conclude our design parameters are approximately correct.

Table: Structural Analysis Results

S.No	Description	Rim	Wheel
01	Max. Displacement (in mm)	0.470E-03	0.240E-04
02	Max. Stress (in MPa)	5.08487	0.285329
03	Max. Strain	0.235E-04	0.180E-05

This process may be incremental but the overall concept requires a shift in the way we think about mechanization for autonomous machines that is based more on needs and novel ways of meeting them rather than modifying existing techniques.

Finally we conclude that Industrial Automation system is an emerging field and there is a huge scope for research and development.

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