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# STRUCTURAL DESIGN AND ANALYSIS OF MAIN AERO CRAFT STRUCTURE AND COMPARISON OF DIFFERENT MATERIALS IN DIFFERENT CONDITIONS.

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**ABSTRACT**

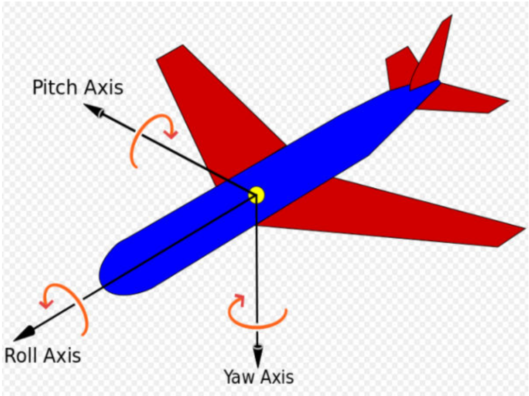
The project deals with the structural design and analysis of Main Aero craft structure (Skin, Floor mounting, Support Lugs) for assembling of electronic packages in a flight vehicle section. The flight vehicle consists of various sections assembled to form an integrated vehicle. Different types of electronic packages to meet the requirements are assembled in different flight vehicle sections based on the flight vehicle configuration. One such type of flight vehicle section needs to be assembled with different electronic packages. The packages have to be rigidly mounted on a mounting structure in the flight vehicle section. The high random vibration loads imparted on vehicle by the electronic packages during launch create an adverse design requirement that all hardware have a natural frequency greater than that of the vehicle, in order to avoid damage and failure due to dynamic coupling. Maximizing natural frequency is generally accomplished by creating as stiff and lightweight a design as possible. However, designing for the resultant high loads also requires a high strength intermediate structure for mounting the various components and subassemblies to the vehicle structure. These two opposing design requirements drive an optimization between a lightweight and high strength structure. The project comprises of design and analysis of the Aero craft structure (Skin, Floor mounting, Support Lugs). The Aero craft (Skin, Floor mounting, Support Lugs) structure has to be designed to withstand the loads generated by the electronic packages. It also includes the design of mounting plate and brackets to withstand the given loads using CAD and CAE tools. CATIA software is used for modeling the flight vehicle section, packages and the mounting plate with brackets. The mounting plate and brackets are imported to ANSYS software for structural analysis. The mounting plate with brackets is applied with specified loads in different flight conditions like Pitch, Yaw and Roll moments. A finite element model was created to manually iterate several aspects of the design, such as geometric characteristics like thicknesses and fillet radii, to analyze the effects on weight and stress and converge on a successful design. The project eludes in detail the methodology adopted for the analysis of Aero craft structures (Skin, Floor mounting, Support Lugs) for flight vehicles and comparison of different materials (Aluminium alloy (2025), Aluminum alloy (23435), Titanium Alloys (Ti4Al4Mo2Sn).

**Keywords** Condition: PITCH, ROLL, YAW.

## 1. INTRODUCTION

An aerodyne vehicle is designed to move in a defined trajectory by means of guidance of control electronic components. These components have to be mounted inside the aerodyne vehicle airframe as per the system configuration. These have to be mounted to withstand aerodyne loads both static and dynamic. The main parts of the anatomy of an airframe are fuselage, the wing and the empennage. Each of these is in turn composed of various structural members. The area of interest in the current project is on the fuselage or the body of the aircraft in which electronic subsystems are mounted. In general, aerodyne vehicle can be an aircraft or rocket or missile. Mass properties are vital for the aerodyne vehicle to travel in desired trajectory. The mass properties of the aerodyne vehicle are Weight, Center of gravity and Moment of Inertia. Weight is the force generated by the gravitational attraction of the earth on the model rocket. The mass (and weight) is actually distributed throughout the rocket and for some problems it is important to know the distribution. But for rocket trajectory and stability, we only need to be concerned with the total weight and the location of the center of gravity. The center of gravity is the average location of the mass of the rocket.

The aerodyne vehicle has three modes of motion viz. Pitch, Yaw and Roll. These terms frequently used in the flight vehicle are explained below. The below figure shows the three modes of motion.




**Three modes of motion in an aerodyne vehicle**

### 1.1 .PITCH MOTION

In aerodyne vehicle, Let consider any aircraft will rotate about its center of gravity, a point which is the average location of the mass of the aircraft. We can define a three dimensional coordinate system through the center of gravity with each axis of this coordinate system perpendicular to the other two axes. We can then define the orientation of the aircraft by the amount of rotation of the parts of the aircraft along these principal axes. The pitch axis is perpendicular to the aircraft centerline and lies in the plane of the wings. A pitch motion is an up or down movement of the nose of the aircraft.

### 1.2. ROLL MOTION

Aircraft will rotate about its center of gravity, a point which is the average location of the mass of the aircraft. We can define a three dimensional coordinate system through the center of gravity with each axis of this coordinate system perpendicular to the other two axes. We can then define the orientation of the aircraft by the amount of rotation of the

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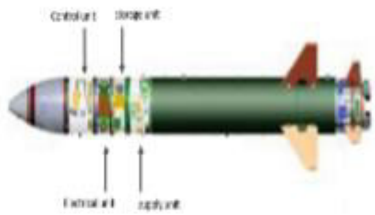
parts of the aircraft along these principal axes. The roll axis lies along the aircraft centerline. A roll motion is an up and down movement of the wings of the aircraft. The rolling motion is being caused by the deflection of the ailerons of this aircraft.

### 1.3. YAW MOTION

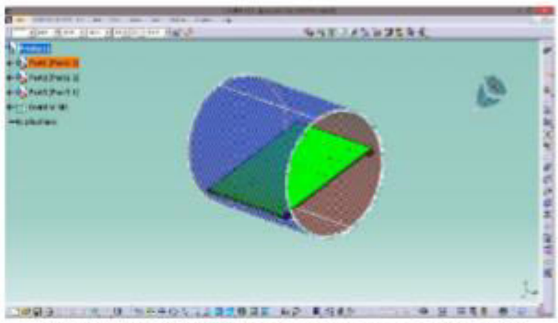
Aircraft will rotate about its center of gravity, a point which is the average location of the mass of the aircraft. We can define a three dimensional coordinate system through the center of gravity with each axis of this coordinate system perpendicular to the other two axes. We can then define the orientation of the aircraft by the amount of rotation of the parts of the aircraft along these principal axes. The yaw axis is perpendicular to the wings and lies in the plane of the aircraft centerline.

## . 2.1. SPECIFICATION OF AERODYNE VEHICLE SECTION

The aerodyne vehicle section has to be mounted with different electronic packages for controlling the flight vehicle in desired path. This section is of **500 mm length** and **420 mm diameter** with **4 mm thick** Airframe. The electronic packages need to be mounted on a rigid structure. A chamber unit need to be designed and analyzed to withstand the flight loads generated during the flight. The web is mounted over four Brackets which are attached to the Airframe forms the chamber unit. The web carries few packages at the top surface and other packages at the bottom surface based on the configuration of the aerodyne vehicle. The aerodyne vehicle section configuration is shown



Figure



**MODEL OF ASSEMBLED PARTS OF PIPE VICE:**

### 2.2. MATERIAL PROPERTIES.

All the components of the Mounting Structure Assembly are made using different materials like Aluminum Alloy (24345), Aluminum Alloy (2025), Titanium Alloy (Ti4Al4Mo2Sn) All the components of the Mounting Structure Assembly are assigned as per the below material properties.

1. Acceleration level experienced by the flight vehicle is 6g.
2. The weights of the packages in Kg are: First: 3, Second: 5.2, Third: 4.3, Fourth: 4.6,

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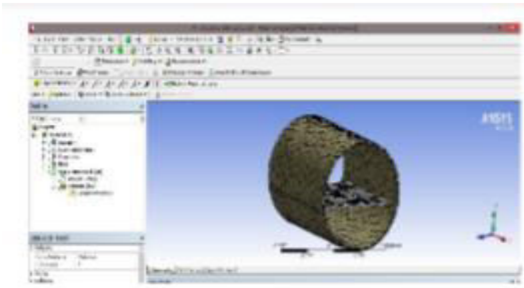
**Finite Element Model Analysis for Chamber Unit of Aerodyne Vehicle**

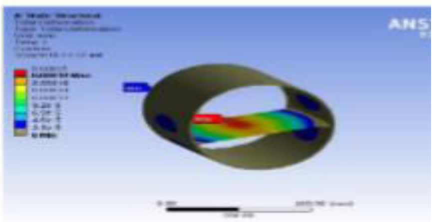
A detailed Finite Element model was built with shell, mass and solid elements to idealize all the components of the Chamber Unit Assembly. The outer shell body and mounting Web are modelled using elastic 4 node 3D Shell elements (Shell 63) a uniform thickness of 4 mm, 10 mm is given respectively. Support Brackets are modelled using a SOLID 10 node tetrahedral element (SOLID 92). Total of 23322 elements are used for this assembly with 2456 elements for the Web and 5147 elements for the Support Brackets and 15719 elements for the total structure.

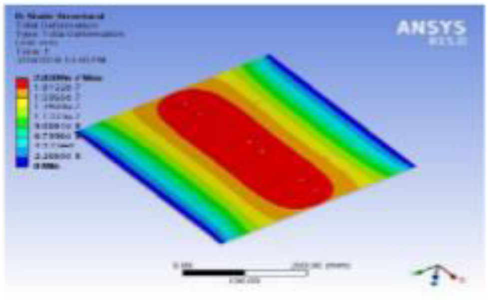


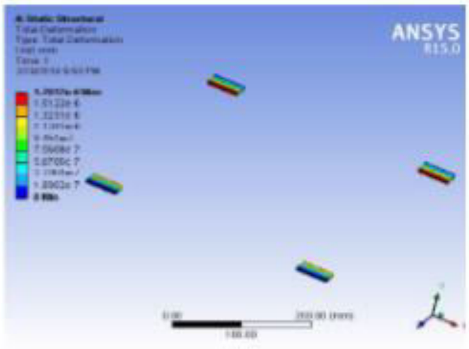
Meshing

**Web & Support Brackets in Yaw Condition Aluminium Alloy (23435)**

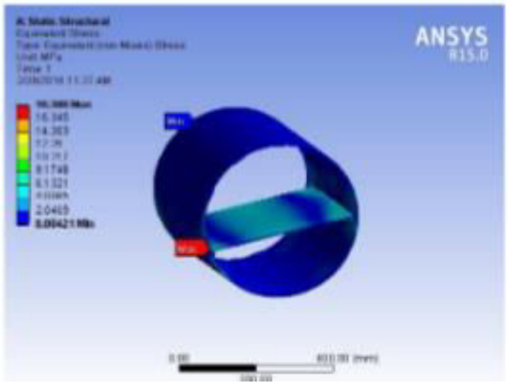
**TOTAL DEFORMATION**

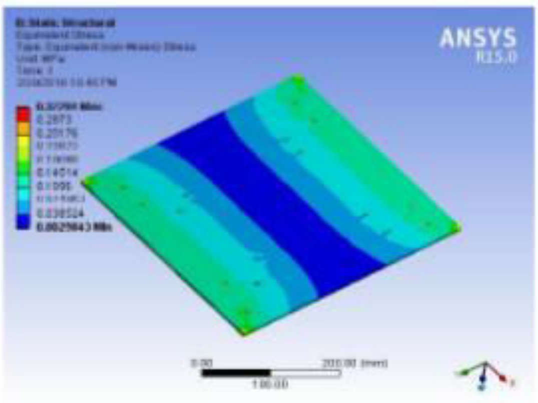





**VON-STRESS**



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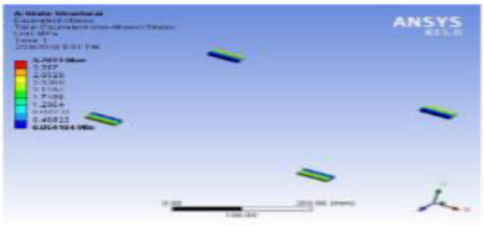
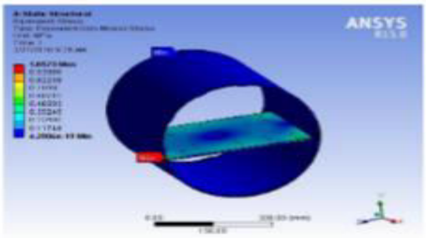
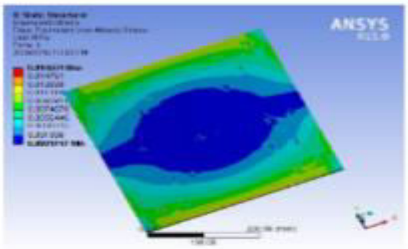
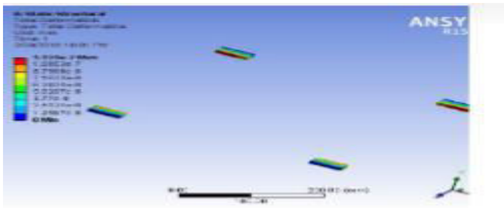



**Web & Support Brackets in Pitch Condition Aluminium Alloy (2025)**

**TOTAL DEFORMATION**



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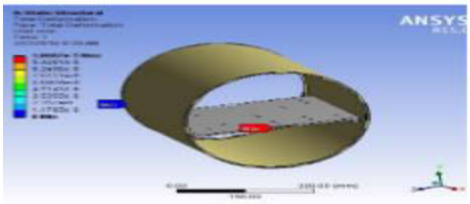
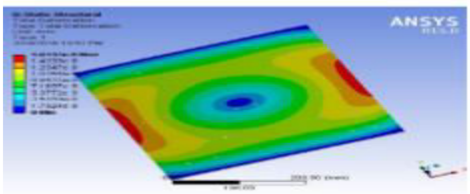
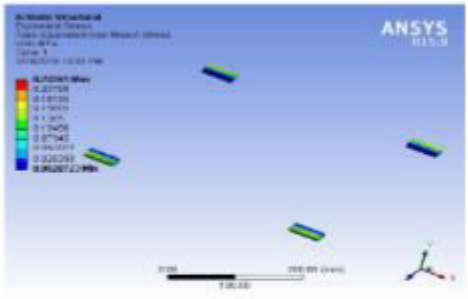
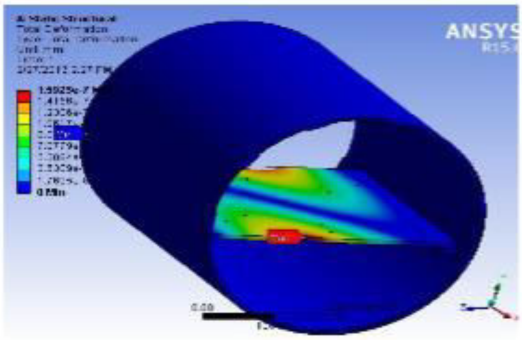


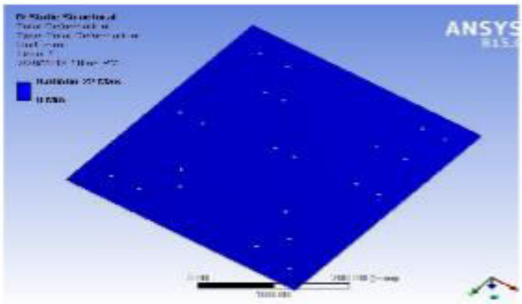


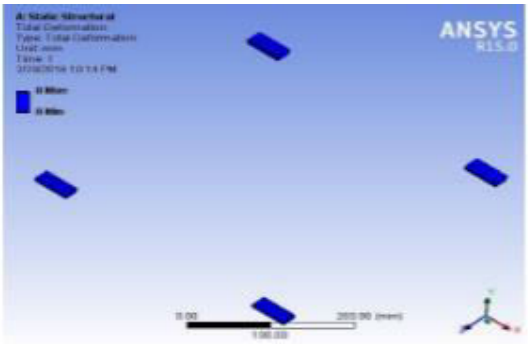




**SUPPORT BRACKETS IN ROLL CONDITION TITANIUM ALLOYS (TI4AL4MO2SN)**

**TOTAL DEFORMATION**







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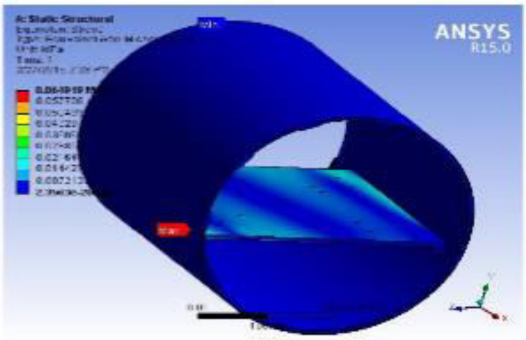
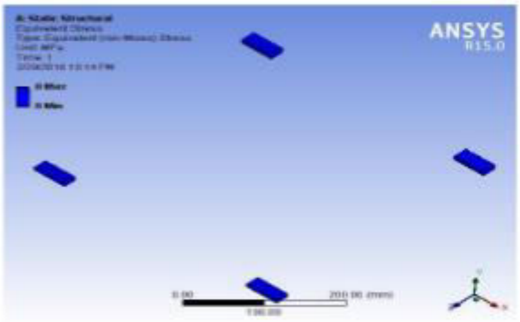
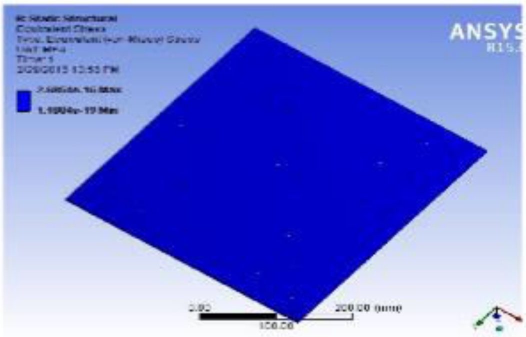
VON-STRESS




**Comparison Different Materials in Yaw Condition (Total Deformation)**:-

| Structures | Aluminum alloy (2025) | | Aluminum alloy (23435) | | Titanium alloys (Ti4Al4Mo2Sn) | |
|---|---|---|---|---|---|---|
| | **Min** (Mm) | **Max** (Mm) | **Min** (Mm ) | **Max** (Mm ) | **Min** (Mm ) | **Max** (Mm ) |
| **Chamber Unit** | **0** | **0.0002076** | **0** | **0.00019** | **0** | **0.00011** |
| **Web** | **0** | **2.276e-7** | **0** | **2.0399e-7** | **0** | **1.239e-7** |
| **Support Brackets** | **0** | **1.8981e-6** | **0** | **1.7012e-6** | **0** | **1.0154e-6** |

**Conclusion: -**

- Finite element analysis plays a very vital role in design of the mounting structure used for flight vehicles and forces developed due to pitch, roll and yaw conditions.
- Comparing three different materials **Titanium alloys (Ti4Al4Mo2Sn)** is best.

| Structures | Yaw Condition | | Pitch condition | | Roll condition | |
|---|---|---|---|---|---|---|
| | Total Deformation (Mm) | Von-Stress (Mpa) | Total Deformation (Mm) | Von-Stress (Mpa) | Total Deformation (Mm) | Von-Stress (Mpa) |
| Chamber Unit | 0.00011 | 18.026 | 5.860e-6 | 1.0751 | 1.5925e-7 | 0.064919 |
| Web | 1.239e-7 | 0.31975 | 8.905e-9 | 0.016529 | 9.6656e-22 | 2.68554e-16 |
| Support Brackets | 1.0154e-6 | 3.6119 | 6.0549e-9 | 0.22215 | 0 | 0 |

Von-misses stress is less their young's modulus. Hence the design is safe. My design is safe.

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