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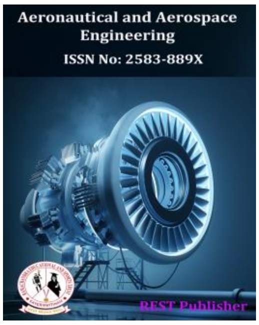

Design and analysis of aerospace payload Structure

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Abstract: *The primary function of aerospace payload structure in aerospace applications is to provide mechanical support and stability to the thruster while withstanding dynamic and thermal loads. These structures must be lightweight yet possess high specific strength and stiffness to ensure optimal performance. Honeycomb sandwich panels are widely used in aerospace payload structure due to their excellent strength-to-weight ratio, fatigue resistance, and energy absorption capabilities. In this study, the design and analysis of aerospace payload structure have been carried out. The model consists of a honeycomb core sandwiched between two Aluminium 2024 sheets, providing high structural integrity. The honeycomb core enhances load distribution and impact resistance, while the aluminium sheets ensure durability and heat dissipation. Additionally, parametric studies were conducted by varying honeycomb thickness, aluminium sheet thickness, and the number of supporting brackets to evaluate their effect on mechanical performance. Finite Element Analysis (FEA) was performed to assess the structural response under different loading conditions. Free vibration analysis was conducted to determine the fundamental natural frequency, ensuring that resonance does not affect structural integrity. Static analysis was performed to evaluate stress distribution and displacement under varying thrust loads. The results provide insights into the optimal configuration for a lightweight and structurally efficient aerospace payload.*

Keywords: *Sound Detection, Fixed wing RC plane, UAV, Aircraft object detection, Aerial Acoustic Sensing, Signal Processing.*

1. INTRODUCTION

Aerospace payload structure is a critical structural component in spacecraft, engineered to provide mechanical stability, precise alignment, and effective load distribution for thrusters. Thrusters are essential for various spacecraft functions, including attitude control, orbit corrections, and station- keeping, making the design of their support system a key factor in mission reliability and performance. The thruster supporter must ensure that these propulsion units operate efficiently while minimizing unwanted vibrations, structural stresses, and thermal effects that could impact the spacecraft's overall functionality. During different mission phases, such as launch, orbital maneuvers, and docking, thrusters generate significant forces that must be absorbed and distributed across the spacecraft structure. Additionally, they introduce dynamic loads and vibrations that, if not properly managed, can negatively affect onboard instruments and subsystems. The design of the thruster supporter must therefore account for extreme conditions, including high mechanical stresses during rocket launch, microgravity conditions in space, and thermal fluctuations due to exposure to direct sunlight and deep-space cold. These factors necessitate the use of materials and structural configurations that can withstand the challenges of space environments without excessive deformation or failure

2. METHODOLOGY

2.1 Design Approach: The thruster supporter is modeled in Siemens NX, consisting of a sandwich panel with a hexagonal honeycomb core structure. The outer face sheets are made of Aluminium 2024, chosen for its high strength and fatigue resistance properties. The structure is designed to support axial and lateral thrust forces typical of aerospace engine mounts.

2.2 Material Properties:

- Honeycomb Core: Lightweight composite (assumed properties based on aerospace-grade Nomex or aluminum honeycomb).

- Face Sheet: Aluminium 2024-T3Aluminium 2024-T3,
  - Young's Modulus: 73 GPa
  - Poisson's Ratio: 0.33
  - Density: 2780 kg/m³

2.3 Parametric Study: The core thickness is varied (5 mm, 10 mm, 15 mm), and the Aluminium 2024 face sheet thickness is varied (1 mm, 1.5 mm, 2 mm). A total of nine combinations are analysed.

2.4 Simulation: Finite Element Analysis is carried out using Siemens NX. The boundary conditions mimic real-world constraints, with thrust loading applied to simulate operational stress. Mesh convergence analysis is performed to ensure accuracy.

3. LITERATURE REVIEW

Honeycomb sandwich structures are one of the most efficient and versatile forms of lightweight engineering design used in various high- performance applications. The core idea behind a honeycomb structure lies in mimicking the hexagonal geometry observed in natural honeycombs, which provides exceptional mechanical performance with minimal material use. This geometry enables efficient load distribution and energy absorption while maintaining structural rigidity. These structures are made by placing a lightweight honeycomb core between two face sheets, which are generally stiff and strong materials such as aluminum alloys or carbon fiber composites. The resulting sandwich panel benefits from the core's low density and the high stiffness of the face sheets, leading to an outstanding strength-to-weight ratio The material choice for both the core and face sheets can be adapted depending on the application's mechanical, thermal, or environmental requirements. For lower-load applications, materials like paper or thermoplastics may be used. These are cost-effective and easy to fabricate, but lack the stiffness and strength needed for high-load environments. In contrast, aerospace and military applications rely heavily on high-performance materials such as Aluminum 2024 and Carbon Fiber Reinforced Polymer (CFRP), which offer superior strength, corrosion resistance, and thermal stability. The overall structural performance of a sandwich panel is highly dependent on parameters such as cell size, cell wall thickness, core density, and the adhesion between the core and face sheets. Increasing core density improves compressive strength and energy absorption, while varying cell geometry affects buckling behavior and stiffness. According to the ASTM definition, a structural sandwich is a type of laminated composite consisting of multiple layers of different materials bonded together to capitalize on each material's mechanical advantages. The bonding process, which may use adhesives or co-curing techniques, ensures that the structure behaves as a single unit under load. In addition to providing mechanical benefits, honeycomb sandwich structures offer functional advantages such as acoustic and thermal insulation, damping of vibrations, and resistance to fatigue and impact. These features make them attractive not only in aerospace but also in automotive crash structures, marine hulls, and wind turbine blades.

4. METHODOLOGY AND DESIGN

Tools and Materials List of Materials: Siemens NX Software: Used for 3D modeling of the thruster supporter and for conducting Finite Element Analysis (FEA). The model includes a honeycomb core structure sandwiched between two Aluminium 2024 face sheets. Computer: A workstation capable of running CAD and simulation tools like Siemens NX efficiently. Design Files: The geometry of the thruster supporter was created in Siemens NX and stored as native CAD files for parametric variation and meshing. Material Database: Material properties for Aluminium 2024 and honeycomb core were sourced from standard databases and manually defined in the simulation environment. Post-processing Tools: Siemens NX's inbuilt post- processing tools were used to visualize and evaluate stress, strain, and deformation. Measuring Tools (Virtual): NX's measuring functions were used to validate the model dimensions and thicknesses during the design process. Simulation Environment: A finite element simulation setup was configured with meshing, boundary conditions, and load applications specific to thruster mounting scenarios. Safety Protocols: While no physical testing was involved, virtual safety checks and model integrity validations were performed within the software.

5. SAFETY PRECAUTIONS

Ventilation: Ensured adequate ventilation in the workspace during CAD modeling and simulation sessions. Eye Protection: Wore safety glasses while handling printed prototypes and during any physical assembly processes. Gloves:

Used protective gloves while managing sharp edges of printed parts and while applying adhesives. Adhesive Safety: Handled adhesives (like super glue) with caution and followed the manufacturer's safety guidelines. Software Safety: Maintained frequent backups of design and simulation files to avoid data loss during modeling and analysis.

5.1 Design and Planning: Selection of Thruster Supporter Configuration: The design of the thruster supporter is based on a honeycomb sandwich panel structure and includes the following key considerations: Face Sheet Material: Aluminium 2024 selected for its high strength, lightweight nature, and aerospace-grade reliability. Honey comb Core: Lightweight core material selected for its high compressive and shear strength and excellent stiffness-to-weight ratio. Variable Thickness: Core and face sheet thicknesses were varied to evaluate mechanical performance under load. Geometry Optimization: The geometry was modeled in Siemens NX for precise control over dimensions and stress distribution. Load Handling: Designed to withstand the load of a propulsion thruster, ensuring structural safety during operation. Modular Design: Allows for easy assembly, disassembly, and material swaps for future optimization studies. Weight Reduction: The sandwich design ensures minimal weight while maintaining structural integrity. CAD-Ready Model: Fully designed using Siemens NX software and prepared for FEA with boundary conditions defined.

6. DESIGN OF THE MODEL

The aerospace payload structure follows a sandwich panel configuration, designed to provide high strength, light weight performance, and structural stability under extreme aerospace conditions. The core of the structure consists of a honeycomb sandwich panel, which offers excellent compressive strength and impact resistance while keeping the overall weight minimal. To enhance rigidity and load- bearing capacity, CFRP (Carbon Fiber Reinforced Polymer) layers are integrated with the honeycomb core. CFRP provides high stiffness, fatigue resistance, and thermal stability, making it an ideal reinforcement for aerospace applications. The entire assembly is enclosed between two Aluminum 2024 face sheets, positioned at the front and rear ends, which serve to distribute loads evenly and provide additional structural protection.

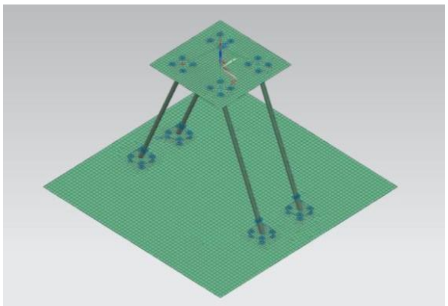

FIGURE 1.

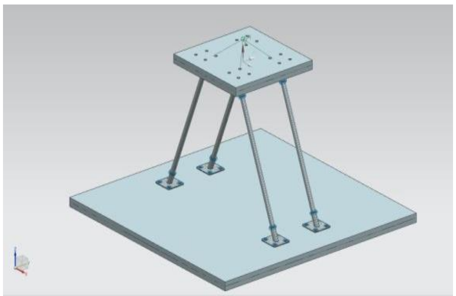

FIGURE 2.

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