OPTIMIZATION OF STIFFENERS ON 3D PRINTED PLA UAV CHASSIS FOR QUADCOPTER

Project Reference No.: *48S_BE_3722*

College : Vidyavardhaka College of Engineering (VVCE), Mysuru
Branch : Department of Mechanical Engineering
Guide(s) : Dr. G V Naveen Prakash
Student(s) : Mr. S Puneet Kumar
Mr. Sathya Kumar S,
Mr. Shashank M P
Mr. Saketh R

Keywords: 3D Printing, UAV, PLA, Stiffener Optimization, Structural Analysis

Introduction

Unmanned Aerial Vehicles (UAVs) are rapidly transforming industries ranging from agriculture and logistics to surveillance and disaster management. As the demand for lightweight, customizable, and cost-efficient UAV structures grows, 3D printing with Polylactic Acid (PLA) has emerged as a promising manufacturing solution. PLA offers ease of fabrication, environmental friendliness, and affordability, making it ideal for rapid prototyping. However, its mechanical limitations—such as brittleness and low stiffness—pose challenges in structural applications. This project addresses these challenges by optimizing the design and placement of stiffeners within a 3D printed PLA chassis for quadcopters. Using advanced CAD tools and simulation techniques, the project aims to enhance the structural integrity, flight performance, and load-handling capacity of the UAV without significantly increasing weight.

Figure 1: Drone

Objectives:

1. To design and optimize stiffeners in a 3D printed PLA UAV chassis.
2. To improve structural rigidity and load distribution while minimizing weight.
3. To perform finite element analysis for identifying critical stress regions.
4. To evaluate and validate the mechanical performance of PLA-only and hybrid (PLA +steel stiffener) configurations.
5. To explore real-world applicability through simulation and prototyping**.**

Methodology:

The project commenced with the development of the UAV chassis model using SolidWorks CAD software. Design parameters focused on motor mounts, battery compartments, and central frame areas subject to stress. PLA was selected for its printability and cost efficiency, and structural steel was introduced later as a reinforcement material. Using ANSYS, Finite Element Analysis (FEA) was conducted to simulate stress, strain, and deformation under operational loads. Various stiffener geometries such as I-beams, L-beams, and ribbed designs were analyzed for performance. 3D printing parameters—like layer height, infill density, and orientation—were optimized for structural integrity. Prototypes were tested under static loading conditions to validate simulations, followed by a comparison of PLA-only and hybrid designs. Static load tests and stress distribution mapping helped in validating the effectiveness of the optimized stiffeners in improving the UAV's structural performance.

Result and Conclusion:

Simulation and testing revealed that the PLA-only configuration, while lightweight (0.199 kg), exhibited higher deformation and lower stiffness. In contrast, the hybrid configuration using structural steel stiffeners significantly enhanced performance. Deformation was reduced by 77% (from 0.082 mm to 0.018 mm), and stress concentration was effectively absorbed in the reinforced regions. Although the mass increased to 0.347 kg, the structural gains were substantial. Strain levels dropped drastically, indicating improved fatigue life and stability. These results confirmed the effectiveness of using localized metal stiffeners in a 3D-printed PLA chassis. The final design ensures strength without compromising the flight payload and endurance, offering a practical approach to UAV manufacturing.

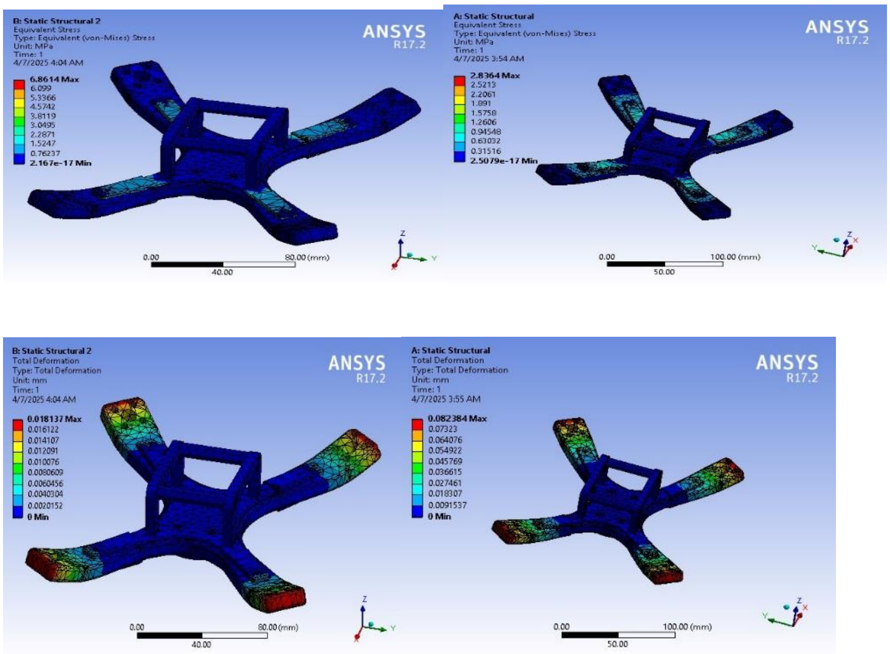

Figure 2: Results

Project Outcome & Industry Relevance:

This project presents a feasible approach to enhance the structural integrity of UAVs using hybrid materials while maintaining the flexibility of 3D printing. The optimized design is suitable for applications in surveillance drones, delivery drones, and precision agriculture. It reduces manufacturing costs and prototyping time while offering structural improvements. The methodology and findings are relevant to industries looking for customizable, cost-effective aerial platforms.

Working Model vs. Simulation/Study:

Working Model – A physical quadcopter chassis was designed, 3D printed, for prototype. It was primarily a simulation and then was printed to check it’s 3D printing properties

Figure 3: 3D model

Project Outcomes and Learnings:

1. Development of CAD models and simulation workflows.
2. Gained practical experience in material testing and structural optimization
3. Understood the limitations of PLA and benefits of hybrid reinforcement.
4. Learned iterative design using FEA and validated results through prototyping

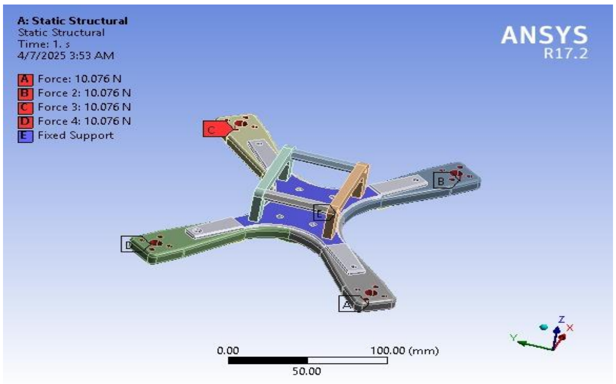

Figure 4: Analysis

Future Scope:

Future work can include dynamic flight testing with onboard electronics and camera payloads. PLA composites and carbon fibre-reinforced polymers could be explored to reduce weight further without sacrificing strength. Machine learning-based optimization could automate stiffener placement for varying flight conditions. Integration of multi-physics simulations (thermal, vibration) and real-time monitoring sensors can enhance UAV reliability. The design may be scaled to larger UAVs or adapted for other drone applications, such as in logistics or environmental mapping. Commercial partnerships with drone startups and defence manufacturers could extend the real-world application of this work.