iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.79070

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

Design and Stress Analysis of Quadcopter Frame

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Abstract: Quadcopter is a type of Unmanned Arial Vehicle(UAV) used across the world in the field of defence , agriculture , surveillance and logistics. The stress analysis is necessary for payload efficieny, flight stability and structureal integrity of the frame. This study presents the design and stress analysis of quadcopter frame for structural reliability under dynamic loading conditions. A 3D CAD model of the frame was developed in Autodesk Inventor Professional 2024 followed by Finite Element Analysis (FEA)(Stress Analysis)to evaluate the distribution of stress , strain and displacement(deformation).Although there are various factors affecting the overall performance of the Quadcopter our work is limited to designing ,modelling and evaluating of the frame analysis.

Keywords: Quadcopter, Frame, Finite Element Analysis, Stress Analysis.

I. INTRODUCTION

Unmanned Arial Vehcile (UAV) also referred drone is one of the advance technologies growing faster in aviation industry. Therefore it is necessary to make a strong quadcopter frame which can be operated in harsh environment. The design and analysis of the drone plays a important role so as to identify how the frame acts in various load conditions. The performance of the quadcopter depends upon the structural design of the frame , the supporting motor , propellers and other electronic items. A frame with high stiffness to weight ratio , resistance to dynamic load , durability is needed which achieve an optimal balance . Finite Element Analysis(FEA) is a powerful tool in Computer Aided Design(CAD) which help us in analysing the designed model without making prototype and helps in reducing the cost of manufacturing for trial. In the early times ,the quadcopter were mainly manufactured with metal , wood or plastic . These material though are available widely they were heavy which reduced the flight time of the quadcopter. But as the metallurgy industry evolved to introduction to composite material they have been widely used in the drone industry which provide hight strength to weight ratio .This encourage the use of composite fibre reinforced polymer , glass fibre in manufacturing drone frame. A quadcopter drone frame is the one which consist of four arm on which the flight motors are mounted. The quadcopter frame also consist of other electronic components. The weight of each components plays a major role in stress analysis developed in the frame and corresponding strain and displacement. Hence the analysis clear the view of how frame react when load is applied on the frame.

II. PROBLEM DEFINITION

The quadcopter frame must withstand the load of the component which is mounted . So the frame must be designed so that Battery , Drone Controller , ESC , Battery , Motor , Propeller are not exposed to the outer environment and design should be strong enough to hold them during flight . Making a prototype of the frame and testing is not economically better and can cause many frame to be manufactured .Therefore CAD provides a platform to design and analysis the frame without any prototype.

III. LITERATURE REVIEW

1) K.Sowjanya & S.Suresh performed a analysis based on the Unmanned Arial Vehicle(UAV).But they consider only aluminium as the frame material.They used Pro/E(Creo. Parametric) for modelling and static analysis is done on CAD/CAE Software.Hence there was the gap between lightweight composites with traditional material for UAV frame.
2) Deva Prakash design a Quadcopter using PID Control Alogrithm.It mainly focused on PID(Proportional – Integral-Derivative) for stabilizing quadcopter.It was a low cost design implemented by microcontroller amid at hover control. When a quadcopter hover at fixed altitude,flight control becomes simple and stability improves.
3) D.Hanafi et al developed a Graphical User Interface(GUI) Controller for quadcopter where the communication between quadcopter and GUI was estaplished through wireless communication.It uses Arduino Uno and IMU(Inertial Measurement Unit) sensor to control the propeller of quadcopter .Analysis showed that the quadcopter is stable upto the impact load of 250 g.
4) K.Sowjanya and S.Suresh analysed the Unmanned Arial Vehicle using CAD and static analysis.Pro-E(Creo) was used for modelling and CAD/CAE software was used for static analysis..Study was limited to material (Cast Iron , Aluminium Composite) without including lightweight composite fibre.

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IV. DESIGN AND METHODOLOGY

The design of the frame involves three main parts.The Base ,Head and Arms.The modeliing is done in Autodesk Inventer Professional 2024.

1) Step 1: Design of parts.(Base, Head, Arm)

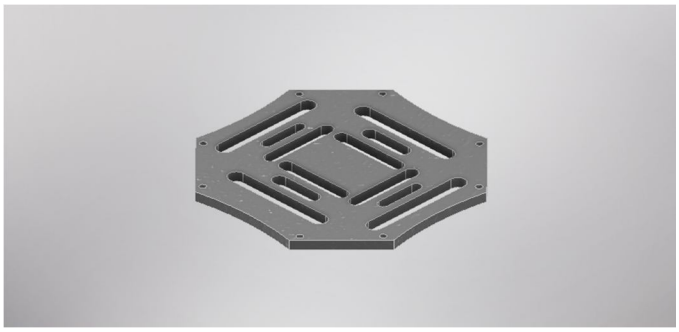


Fig 1 : Head

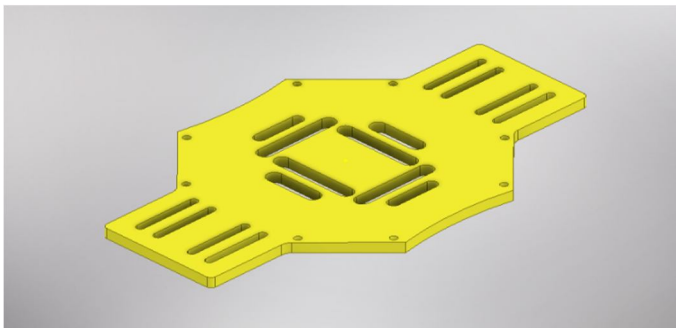


Fig 2: Base



Fig 3:Arm

2) Step 2: Assembly

Once all the parts are modelled ,open the assembly section and import all the parts.Provide necessary constraints to assemble the parts.

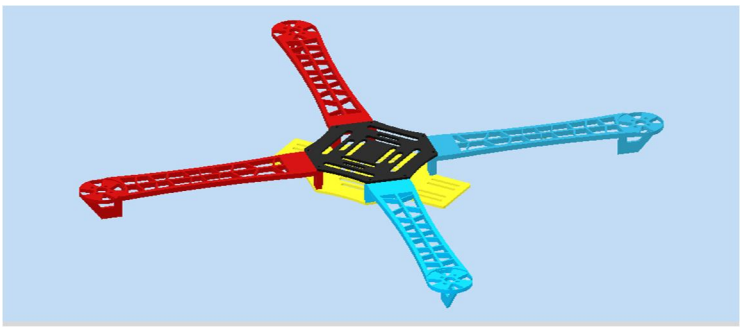


Fig 4: Assembly

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3) Step 3: Material Definition

Define the material to the assembled part of appropriate choice from Inventor Material library.

4) Step 4 : Set Load

Set the amount of force exerted on each arm including the whole structure of the frame .Here we applied 15 N force on each free end

5) Step 5: Run the Analysis

Select the Simulate option and press Run to start the analysis.

V. RESULT

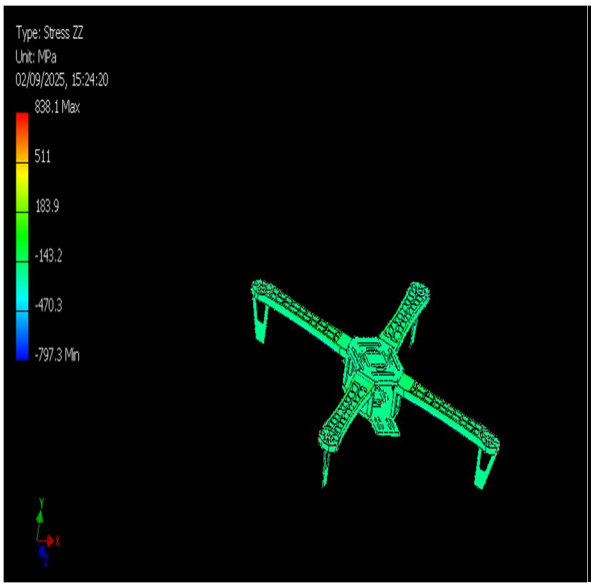


Fig 5: Stress in Composite Fibre

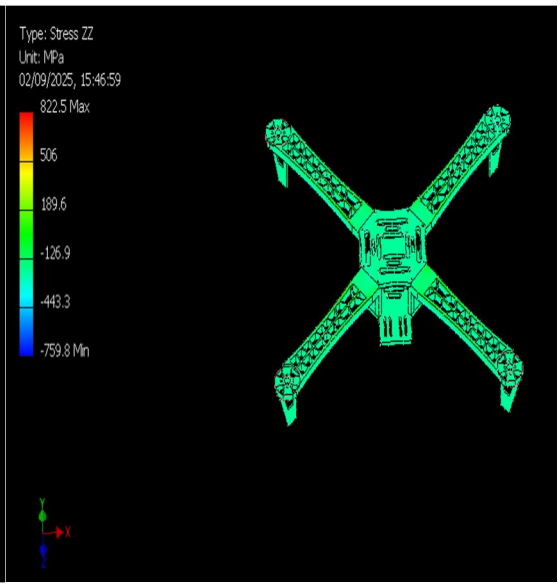


Fig 6: Stress in Aluminium

The stress generated in composite fibre is less than than aluminium.

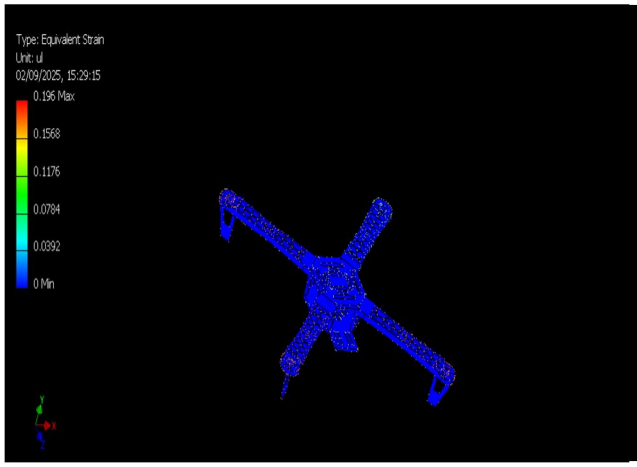


Fig 7: Strain in Composite fibre

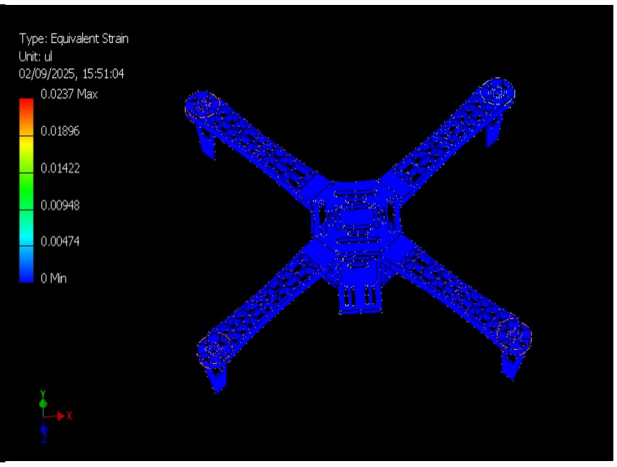


Fig 8:Strain in Aluminium

The strain generated in composite fibre is less than aluminium .

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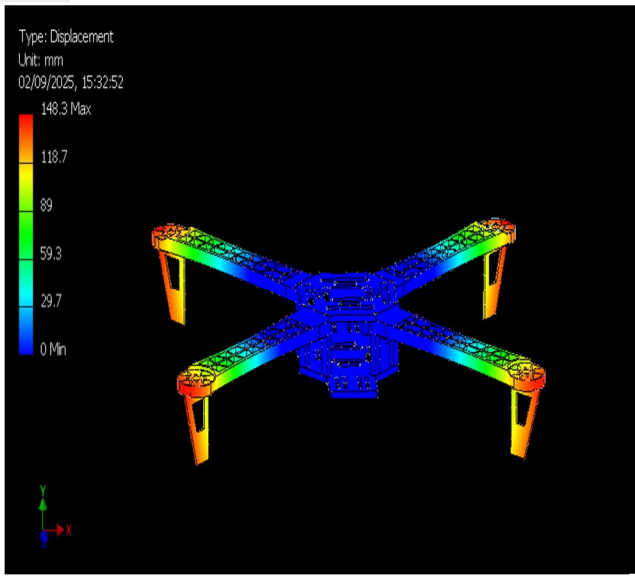


Fig 9 : Displacement in Composite fibre

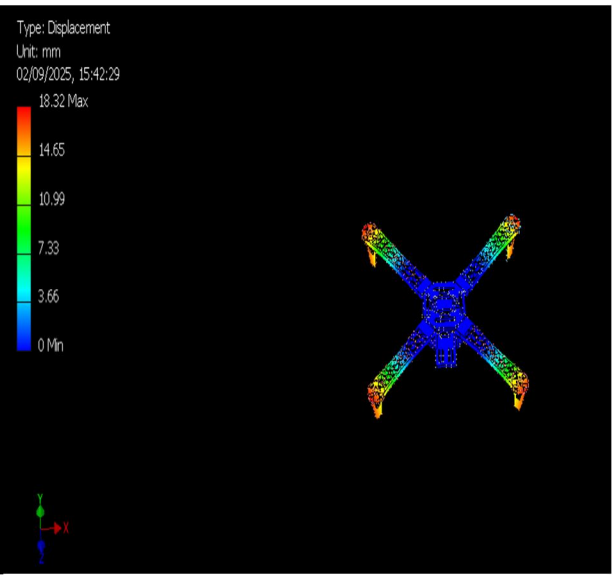


Fig 10 : Displacement in Aluminium

The displacement in composite fibre is more than the Aluminium.

VI. RESULT TABLE

Sr No	Material	Stress(MPa)	Strain	Deformation(mm)
1	Polyamide Nylon	59.3	0.0087	82.8
2	Aluminium	88.6	0.0237	13.87

VII. CONCLUSION

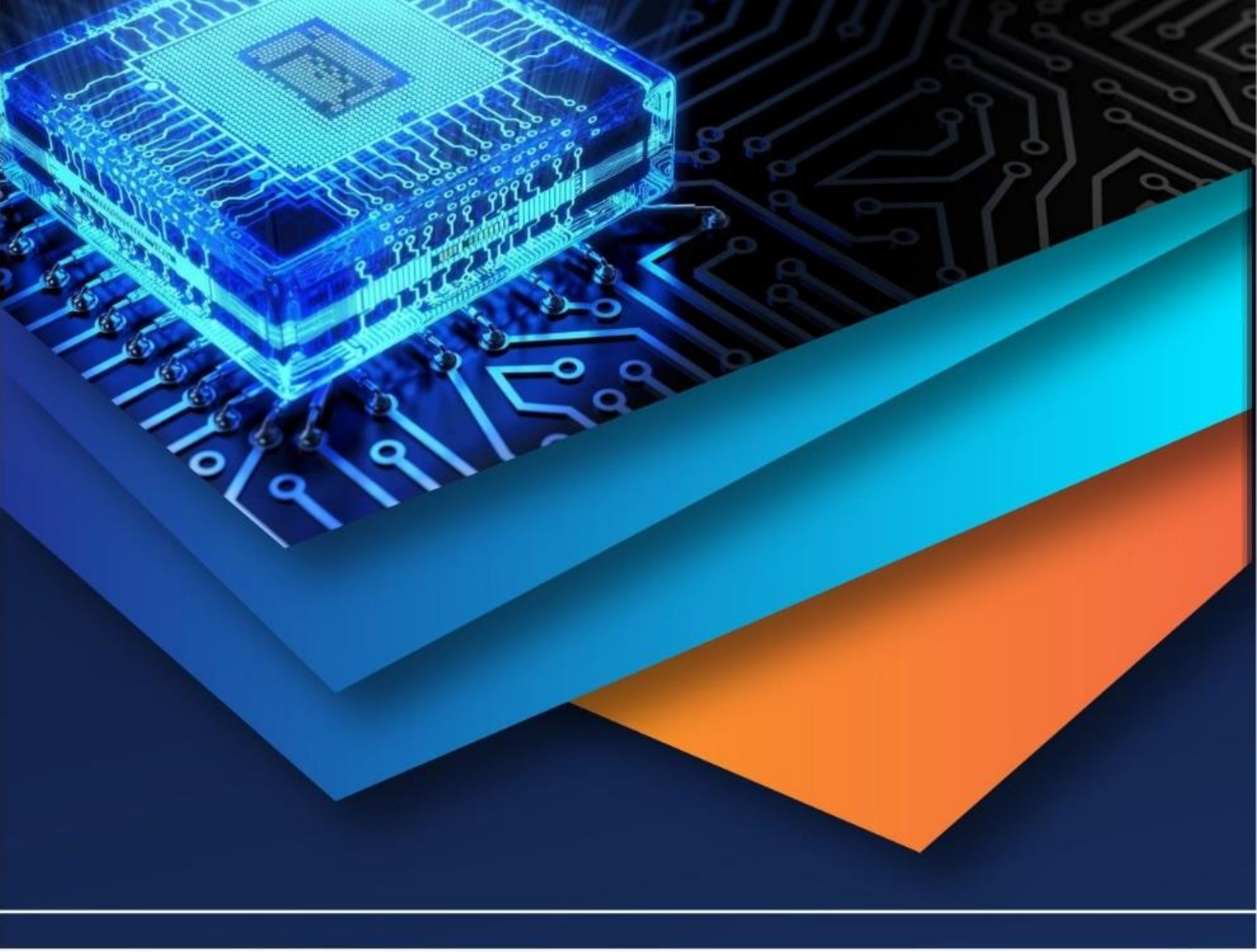
The above design and analysis of the frame in Autodesk Inventor Professional lead to the following conclusion:
The total stress analysis was done in Autodesk Invent0r Professional which concluded that the frame designed lie within the safest limit. The frame can withstand more electronic component apart without affecting the drone structure. As the analysis suggest that the composite fibre is more reliable for futher project ,therefore it was chosen as the material for manufacturing the frame.

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