

Design and Static Structural Analysis of a Quadcopter

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ABSTRACT : A Quadcopter is an elegantly simple design and is hands down the most popular layout for a whole lot of reasons. Quadcopters are symmetrical and embody the simplest principle of operation for controlling roll, pitch, yaw and motion. Experience gained in modifying and implementing a quadrotor, an Unmanned Aerial Vehicle (UAV), is presented. This project uses an innovational quadcopter design with a new streamlined structural geometry. The entire frame is designed using Fusion 360. The new design is validated for its successful implementation through stress analysis using Fusion 360, also suitable material for fabrication is selected by comparing five other materials.

KEY WORDS : Quadcopter, Static Structural, Constraints, Structural Geometry, Design, Analysis

I. INTRODUCTION :

Drones are now being implemented in various fields such as agriculture, mining, surveillance, mapping, reconnaissance, etc. The versatility of drones has been expanding due to the highly advanced electronics available today. Imaging sensors, thermal sensors, passive infrared sensors, obstacle detection are some of the most commonly used ones today. Infrastructure surveillance and maintenance is done with less use of manpower using drones. Critical structures that require a lot of energy and time for inspection such as cable towers, wind mills, solar farms, industrial buildings walls and dams, can be easily inspected with the help of drones. This paper uses a new streamlined geometry which has been designed to be fully sealed to carry the components and all the circuits. This is done in order to fully protect the circuits. The model will be designed based on a basic quadcopter. The frame size, position and angle of arms will all be decided based on the

propeller size to prevent interference between propellers and with the propeller and the frame. The entire frame will be modeled using Fusion 360. Using the chosen material's properties the weight of the structure will be estimated. The structural stability of the drone plays an important role as its application involves exposure to different pressure environments. The stability of the frame will thus be validated using analysis through software. The entire frame of the drone is subjected to static structural analysis using Fusion360.



Figure 1 : Quadcopter

II. PROBLEM DEFINITION :

The main requirements for a drone to be able to travel in air is to have the ability to withstand the pressures which will be experienced in air and the electronic components should also not be exposed to the atmosphere as it may damage it. So the design should be made in such a way that the electronic components like ESC, FC, battery, etc., are not exposed to atmosphere and the frame should be able to withstand air pressure till certain height. Testing quadcopter every time is costly affair hence numerical simulation provides the better and cheap way to design.

III. ANALYTICAL METHOD:

- **Design of the Frame :** The drone was designed using Fusion 360 software by taking the mission requirements into consideration. The frame and component tray part of the frame was designed separately and they are to be attached with screws. The motors for operation of the drone will be fit securely within the motor holders which were alsodesigned.

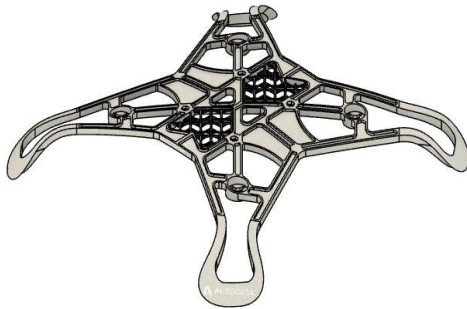


Figure 2: Frame

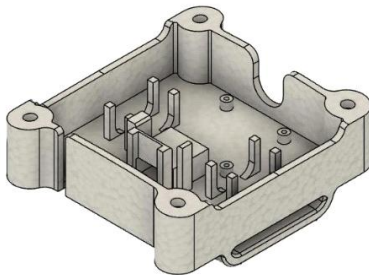


Figure 3: ComponentTray

- **Material Selection :** Depending upon the usage material is selected, Various materials possess various properties. The most common used materials in the drones are CFRP, ABS Plastic, Aluminium AlSi10mg, Polystyrene, Nylon6,6.

S. No.	Material	Weight Estimation of Quadcopter (gm)	Density of the material (gm/cm ³)
1.	CFRP	408.986	2.0
2.	ABS Plastic	303.164	1.08
3.	Aluminium AlSi10Mg	763.632	2.69
4.	Polystyrene	292.011	1.06
5.	Nylon 6,6	323.184	1.31

Table 1: Material and Properties

- **Static Structural Analysis:** A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant

inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect totime

- **Load Case :**

- **Load :** Due to the static condition the quadcopter located on the ground has to move towards the thrust direction produced by the motors. So the load at each entity can be of 340 grams including batteries and electronic circuits. So each entity has a load of 3.3354N.

- **Constraint:** The quadcopter which is located on the ground due to the static condition the component tray is said to befixed.

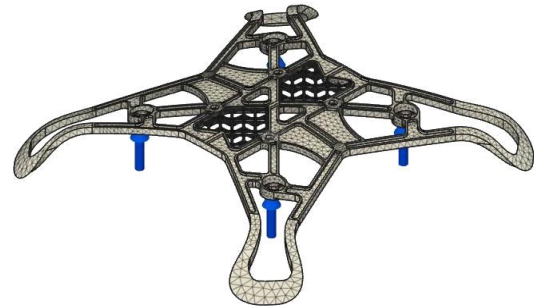


Figure 4 : Meshed Framewith load

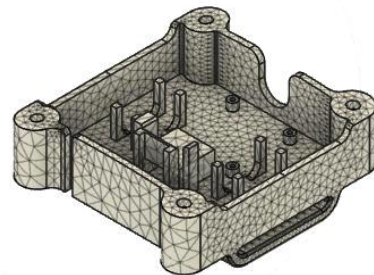


Figure 5: Meshed Component tray with fixedconstraint

Component	Weight (gm)
Frame and Component tray	350
Battery	260
Motors	120
ESC and Flight Controllers	300
Propellers	24
Camera and Circuits	250

Table 2 : Weight Estimation

IV. RESULT AND DISCUSSION

The total deformation, reaction forces, contact pressures, principal stresses, for the above

mentioned loading conditions and materials were obtained using structural analysis tool in Fusion 360 . The deformation results are shown in the figures below. The deformation values are shown in table3.

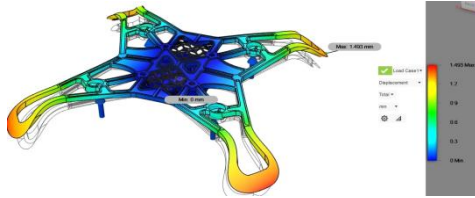


Figure 6 : ABS Plastic - Total Deformation.
 Figure 7 : Aluminium AlSi10Mg-Total Deformation

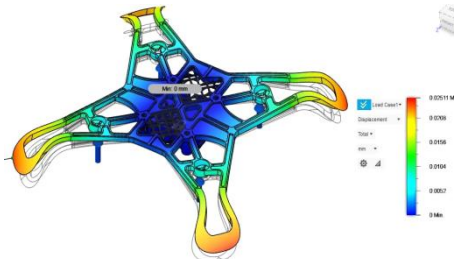


Figure 8 : CFRP-Total Deformation

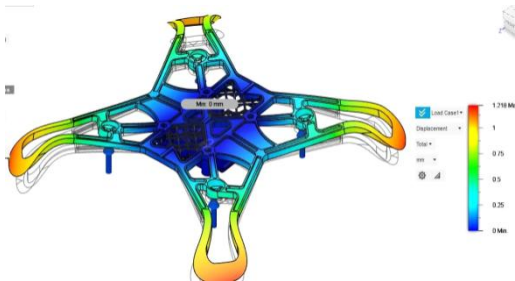


Figure 9 : Nylon 6,6 - Total Deformation

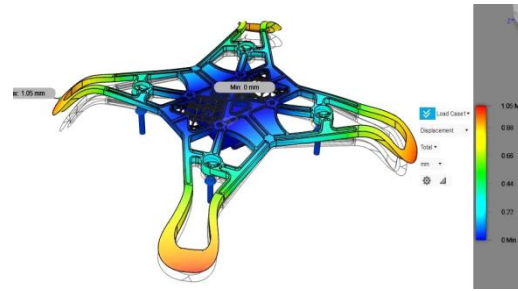


Figure 10 : Polystyrene - Total Deformation

S. No	Material	Total Deformation (mm)	Contact Pressure (Mpa)	Reaction Force (N)	Vonmises Stress (Mpa)
1.	CFRP	0.025	2.549	0.5155	5.748
2.	ABS Plastic	1.493	2.507	0.5031	5.749
3.	Aluminium AlSi10Mg	0.047	2.331	0.5027	5.771
4.	Polystyrene	1.05	2.406	0.4997	5.758
5.	Nylon 6,6	1.218	2.395	0.5089	5.759

Table 3 : Deformation Values

V. CONCLUSION

The center of gravity was calculated and it was found to satisfy the balancing condition for this case. From the total deformation results obtained in Fusion 360 we inferred that the deformation for all the chosen materials was within negligible limits. Therefore the most suitable material was chosen based on the weight of the frame. Since polystyrene gives a lighter structure compared to the others it was chosen for fabrication of the drone. Polystyrene not only gives a lighter and stronger structure, it additionally proves to be corrosionresistant.

VI. FUTURESCOPE

- The model will be fabricated with the chosen material and subjected to flight tests in air and water.
- GPS technology with geometrical reasoning can be implemented to remove limitations due to remote operation.
- Improved underwater imaging can be provided with acoustic imaging.

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