



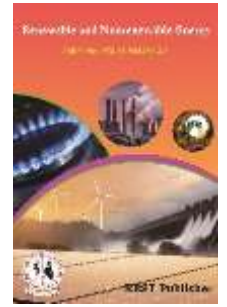
Renewable and Nonrenewable Energy

Vol: 5(2), 2026

REST Publisher; ISBN: 978-81-948459-2-8

Website: <https://restpublisher.com/book-series/ese/>

DOI: <https://doi.org/10.46632/rne/5/2/12>



Design and Development of a Micro Quad Copter Using Rapid Prototyping Techniques

*K Kalyani Radha, B Omprakash

JNTUACEA, Ananthapuramu, Andhra Pradesh, India.

*Corresponding Author Email: radha.mech@jntua.ac.in

Abstract: Quad Copter is a novel appearance Superior performance VTOL aircraft which has a simple structure flexible operation high load capacity and other characteristics have important civilian and military value. Over the past decade the Quad Copter has become the standard platform for micro aerial vehicle (MAV) research and aerial robotic projects. The search for advancement in technology has led this project to adopt rapid prototyping in fabrication. In this project the designing and analysis of main structures of quad copter has done according to the requirement, and the mechanical structures of the Quad Copter has been fabricated by using 3D Printing method provides us the less weight and complex structures. Fill density parameter will provide the various strength specimens in printing. These specimens tested for mechanical properties and evaluated to the real stress and loads acting on it. This is a result of the simplicity and effectiveness of the Quad Copter design, the decrease in component costs, increase in performance and capability of the components.

Keywords: Quad Copter, Mechanical structure, 3D printing, fill density, complex strength

1. INTRODUCTION

Micro aerial vehicles are aircrafts capable of flight without an on-board operator. Such vehicles can be controlled remotely by an operator on the ground, or autonomously via a pre-programmed flight path. MAVs are already being used by the military for recognizance and search and rescue operations. The project is to design and build a Quad Copter MAV. Our proposed design is for a micro, lightweight, nimble craft that can be operated both indoors and outdoors. The project poses particular challenges in terms of weight reduction and controllability as the size of the Quad Copter has been scaled down. Quad Copter crafts generally support only a light payload, as they are required to carry the weight of the power supply, a heavy battery, on-board. Thus, weight reduction of all components is essential in order to allow for sufficient lift force. The controls system for such a craft is also complex, as it requires the synchronization of four individual motors. These motors must be closely controlled in order to account for variations between the motors (one motor slightly more powerful than the others will upset the equilibrium of the craft), and in order to effectively dampen external disturbances. I succeeded in building a craft structure that was both stiff and lightweight, using a unique and upgrading technology called rapid prototyping. This rapid prototyping technology includes many techniques like FDM, SLS, 3D Printing, SLA etc. among all techniques I adopted 3D Printing for my project. I started this project because I wanted to build my own Quad Copter, as many people in this hobby has done. Instead of cutting metal tubes and screwing everything together to make a robust structure, I was thinking about something a bit more modular and with less screws. Something that could be transported anywhere easily and require no tools to prepare on-the-field. Having a 3D printer on the desktop had opened me the doors to imagine all sorts of new pieces and mechanisms. Because I like to give a try to even the oddest idea, the project grew bigger, and lasted much more than the expected. Although I've spent much more hours developing it than flying it, I think the 3DMAV is a great success and I've learned a lot from it.

2. LITERATURE REVIEW

Universities like Manitoba, Colaredo, and Mit are doing research on 3d printed UAV (unmanned air vehicle) for advancement in technology. University Of Adger conducted a Modelling, Design and Experimental Study for a Quad copter System Construction

Government organizations and private companies like J Robotics, IE labs, NAFEMS, ESCI like Organizations are working on development of 3D printing technology, government institution like IIT's, NIT's and some Universities are working parallel with the researchers to bring awareness about the technology , lot of private companies and Non profitable organizations are in the development of 3D printed Quad copter.

3. DESIGN OF QUAD COPTER FRAME IN CATIA V5

CATIA is mechanical design software. It is a feature-based, parametric solid modelling design tool that takes advantage of the easy-to-learn Windows graphical user interface. You can create fully associative 3D solid models, with or without constraints, while using automatic or user-defined relations to capture the design intent. 9 CATIA acts as the backbone for concept, product definition, manufacturing, simulation, and after-market information found within various lifecycle stages of a product. 9 It provides the specifications and geometrical data related to a product across several lifecycle phases.

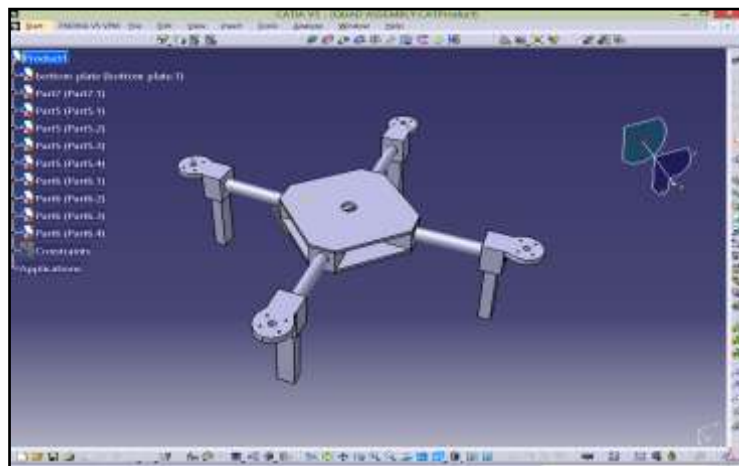


FIGURE1. design and assembled Quad copter structure

After designing the file has to save in its format for easy loading to ANSYS Workbench.

4. ANALYSIS OF FRAME

In ANSYS workbench the details required like material properties, thrust produced by the motor mounted at the ends, self-weight all parameters has to provide for the processing.

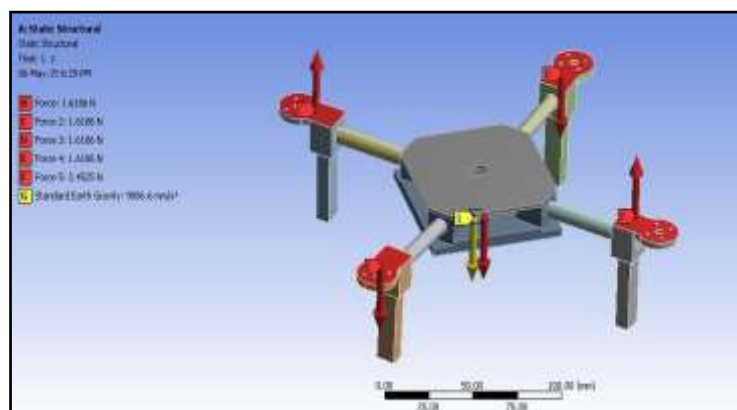


FIGURE 2. Loads on Quad copter structure

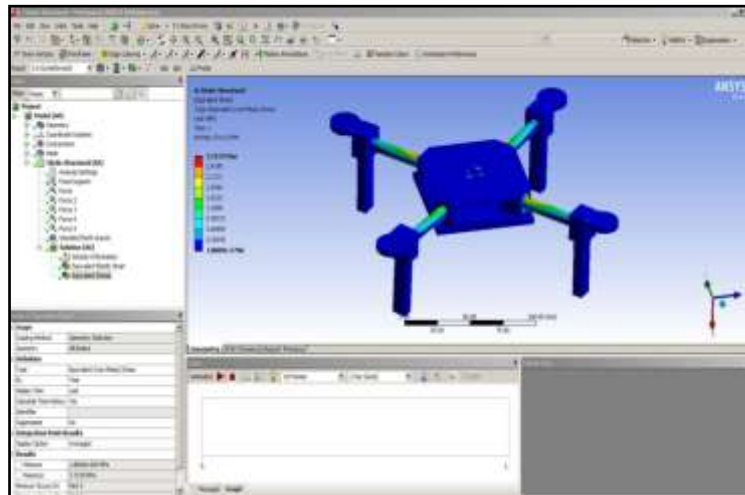


FIGURE 3. vonmises stresses on the structure

Results from Ansys:

- Compressive yield strength = 42 Mpa
- Tensile yield strength = 40Mpa
- Tensile strength = 45 Mpa
- Compressive ultimate strength = 42 Mpa

5. FABRICATION IN 3D PRINTER

Steps followed in 3D printing process: Design of component → STL file conversion → G Codes → Printing.

G codes specifications:

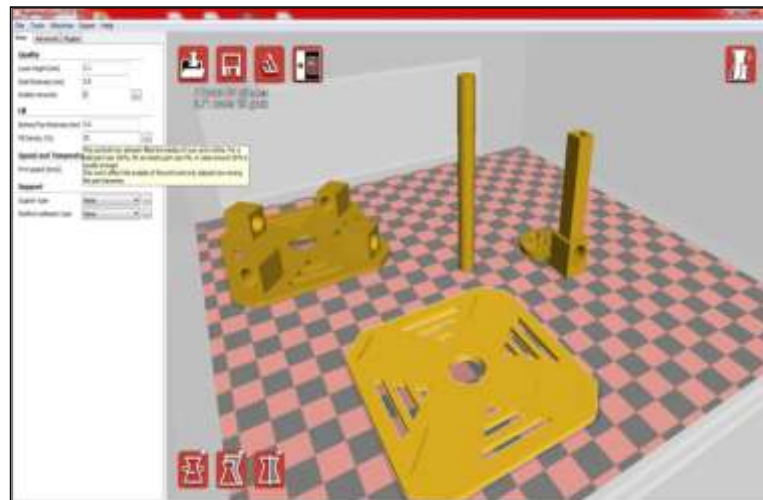


FIGURE4. G codes entry for printing

Cura software specifications

- *Basic*
- *Quality*
- Layer height (mm) = 0.1
- Shell thickness = 0.8
- Enable retraction yes
- *Fill*
- Bottom / top thickness (mm) = 0.6

- Fill density (%) = 20
- *Speed & Temperature*
- Print speed (mm/s) = 50
- *Support*
- *Support Type* Default
- Platform allocation type default
- *Advanced*
- *Machine*
- Nozzle size (mm) = 0.4
- *Quality*
- Initial layer thickness (mm) = 0.3
- Initial layer line width (%) = 100
- Cut off object bottom (mm) = 0
- Dual extrusion overlap (mm) = 0.15
- *Speed*
- Travel speed (mm/s) = 150
- Bottom layer speed (mm/s) = 20
- In fill speed (mm/s) = 0.0
- Top /bottom speed (mm/s) = 0.0
- Outer shell speed (mm/s) = 0.0
- Inner shell speed (mm/s) = 0.0
- *Cool*
- Minimum layer time (sec) = 5
- Enable cooling fan yes

In these specifications we are giving instruction to the software for smooth printing. Here we are considering 20% of fill density. The total weight of the components will be 96grams at 20% of fill density.

6. TESTING AND CALCULATIONS

The Printed specimen in 3D printer with dimensions tested on universal tensile tester for plastics.

- Original length of specimen $L = 80\text{mm}$
- Diameter of the specimen $d = 8\text{mm}$
- Average Elasticity
- modulus = 75.454
- N/mm^2
- Total change in length = 37mm
- Final neck diameter = 3.89mm
- Breaking load of the specimen
- Ultimate load of the specimen = 600N
- Final length of the specimen = 11.7cm
- Elongation % = $((L_f - L_0)/L_0) \times 100 = ((11.7 - 8)/8) \times 100 = 46.25\%$
- Ultimate stress = ultimate load/area = 11.9476 N/mm^2
- Breaking stress = Breaking Load /area = 445/50.24 = 8.492 N/mm^2

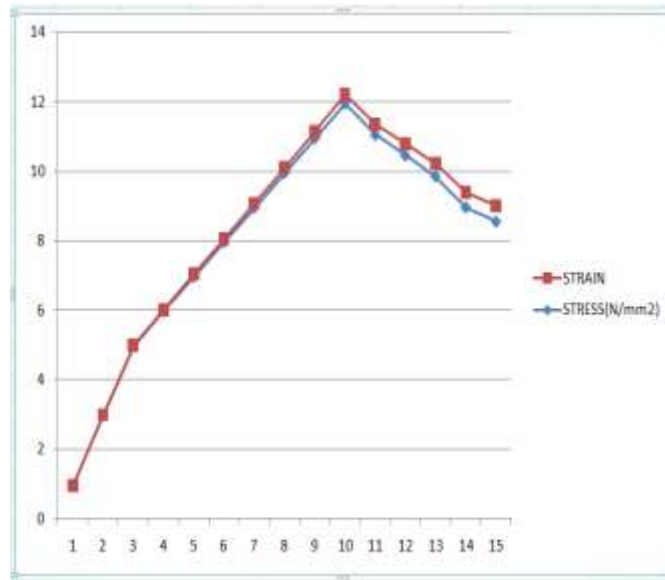


FIGURE 5. stress-strain curve of ABS material at fill density 20%

7. RESULTS AND DISCUSSIONS

At 20% of fill density the weight of the structure is 96 grams and it's bearing the load 600grams of pay load. In the scientific laboratory the specimens with 30%, 40%, and 50% fill density also checked for tensile and compressive strength. Those results are given below:

TABLE 4 Variation in Properties with Change in Fill Density

Fill density/properties	20%	30%	40%	50%
Ultimate stress(N/mm ²)	11.9476	12.526	13.783	14.825
Breaking stress(N/mm ²)	8.492	9.215	9.894	10.647
Elongation %	46.25	43.15	40.12	38.94
Elasticity modulus(N/mm ²)	74.454	78.624	82.897	88.125

At maximum fill density more strength will be in 3D printed parts as shown in the table, but when fill density is high there are some difficulties while printing those are:

- Material will flow out from the dimensions.
- More time will consume.
- Poor dimensional accuracy.
- Wrapping will occurs vigorously.

So, to overcome these difficulties the suggested fill density is between 35-48 % for ABS material. And the weight of structure will be rounded to 96 grams and strength will improve.

8. CONCLUSIONS

A Quad copter structure was built in 3D printing machine, tested individual parts of Quad copter. The results obtained are favourable to test the Quad dynamically, then the Quad copter assembled structure with the accessories and tested the flight time, payload carrying and landing prospects. The best results of the Quad copter structure obtained at 35%-48% fill density while printing the structure of Quad copter. So, by considering fill density parameter in 3d printing the weight of Quad copter reduced, the strength and complexity of structure improved drastically.

REFERENCES

- [1]. V. Ross. (2011, August) In development: *Networks of unmanned quad copters to ferry medicine to isolated areas*. *Discover Magazine*. Accessed: September 2012. Available: <http://blogs.discovermagazine.com/80beats/2011/08/30/in-development-networks-of-%20unmanned-quadcopters-to-ferry-medicine-to-isolated-areas/#.UTqfsxxgCXg>
- [2]. Peukert's law, a nerd's attempt to explain battery capacity," accessed:
- [3]. September 2012. [Online]. Available:
- [4]. <http://www.batterystuff.com/kb/tools/>
- [5]. Peukert-s-law-a-nerds-attempt-to-explain-battery-capacity.html.
- [6]. S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," *IEEE Electron Device Lett.*, vol. 20, pp. 569–571, Nov. 1999.
- [7]. *Strength of materials* book by R K Bansal, *fifth edition in year 2012*.