Design & Analysis of Multi-Frame for Octo & Quad Copter Drones

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Abstract - *Now a day's multi-rotor commonly known as drones, are attracting much attention in media and research. Many industries are interested now in using drones because they are fast, cost-effective and efficient solutions. There are many different applications for drones such as parcel delivery, rescue operations, construction drones, infrastructure inspection, military operations, agriculture monitoring and many more. This is very attractive opportunity for entrepreneurs and drone market is growing very fast. Whether it is a new initiative within a company or a new start-up, the problem really is what drone application is worth to develop. At present, drone application are many in 21st century but the cost of the drones are very high, so in this paper we are trying to reduce the cost of the frame and we are focused only on frame of heavy Octocopter drones which will replacing the Carbone fiber pipe to the aluminum pipe with simple design concept of the drone and compacting the overall size of the drone frame and joining with the 3D printed plastic parts. Our aim in this paper work is we are trying to reduce as much as possible weight and cost for the Octocopter drone frame and easy to manufacturing and assembling the frame are consider while designing the frame of the drone. The design is arrange in a simple way such that we can easily separate in two quad copter or easily combine in one octocopter like that multi-functional frame design is arranged with the all parameters are consider such that payload, battery, motors, propellers and electronic control units etc. The frame is design in CATIA V5 CAD software and static analysis is done in ANSYS 19.2* software and find out the total deformation and stress in the frame body of the drone.

Key Words: Quad copter drone, Octo copter drone, multi-frame, CATIAV5, ANSYS.

1. 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.

Drones come in a variety of designs, such as a fixed-wing drone, which looks like a plane, or a rotorcraft drone, which looks similar to a helicopter, though often with multiple rotors (usually up to eight). The latter has vertical takeoff and landing capabilities and it can hover, which makes this design particularly attractive in close quarters, such as crowded urban areas. Tilt-wing drones combine features of fixed-wing and rotorcraft drones using wings that can be swiveled. Drones may use different types of propulsive power, including internal combustion engines, electric batteries, and solar and hydrogen fuel cells

1.1 Quad copter drone

The most popular multi-copter on the market Quad copters is fast, easy to manufacture and affordably priced. These copters utilize four propellers to ensure that the aircraft is able to lift up into the air.

Essentially, there is a 4 propeller layout in the design of a square or rectangle around the body.

Fig -1: Quad copter drone

The one obvious benefit is that with four propellers, the product has a lot more power to be able to lift off of the ground this allows for more payload or overall weight to be added.

Drones often use this design simply because it can hold a lot of weight without raising the price of the product drastically.

- Relatively cheap to manufacture.
- Great maneuverability.
- Powerful enough to add accessories.
- Greater thrust and power versus tri-copters

1.2 Octo copter drone

The octocopter has all of the benefits seen with the hexacopters, but with even more power. These models are not cheap by any means and are often seen capturing the best aerial footage available. If you're a professional videographer, you may want to hold onto your hat because what the octocopter has to offer is simply stunning. Design-wise, this copter features 8 motors and propellers. These 8 motors provide the same benefit that the hexacopter provides over the quadcopter

Fig -2: Octo copter drone

- *Speed*: Much faster than the competition and Reach higher altitudes
- *Control*: Terrific control that is not hindered as much by wind or rain and More powerful and reliable
- *Safety*: You can lose any one motor and still fly these copters just as well as you could a hexacopter. Furthermore, you may be able to lose 2 or 3 motors without the craft crashing down, depending on positioning and the overall payload and Very stable flyers, handle better in adverse weather conditions

2. PROBLEM STATEMENT

In this study, the focus is on the use of drones for industrial works and more specifically for multi-purpose application as per the customer required to use in different conditions like heavy and light payload operating of drone for the industrial works and it should be easy and simple design as per the customers required to assembling the drone part frame and others all parameter of the drone.

As per the previous studies, the payload observed for the drone in Indian manufacturing sector was restricted. So I was given a task of improving the payload capacity for the drone. To ensure the same, I was asked to go through the various aspects of design concepts and manufacturing processes to be used.

3. OBJECTIVE

- To design simple and multi-functional frame for higher weight capacities (Here – 2.5 kg)
- Simple yet aesthetically appealing design
- Should be cost effective
- Easy to assemble and dissemble

4. DESIGN

In this paper we have design the quad drone frame in the CATIA V5 CAD software as per the shown below figures there are two type frame design as lower frame and upper frame which is easy to assemble the parts from the packing box and the materials is used as per low cost of manufacturing in which the pipe are use of aluminum material and joint plastic parts are made by 3D printed with 70% fill material which is quite stronger to the strength and we get much reduced weight for the frame design.

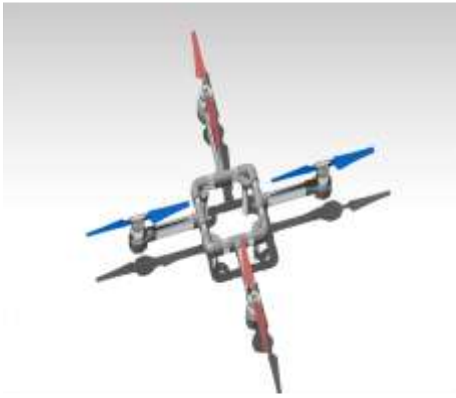

Fig -3: Upper Quadcopter drone frame

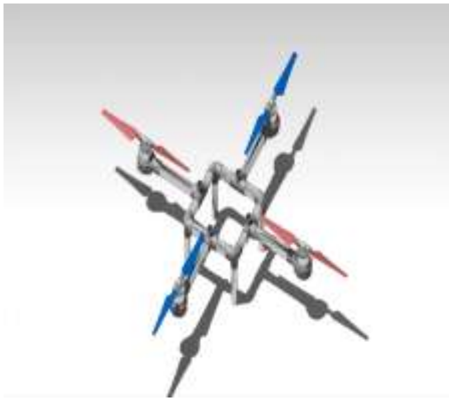

Fig -4: Lower Quadcopter drone frame

In the above shown fig no. 3 & 4 quadcopter frame is combining and made octocopter frame as shown below figure which made in CATIAV5 CAD software. The offset distance between upper and lower motor is 80mm which shown in octocopter side view and total length between two motor is 600mm which is seen in octocopter top view. It is shown in below fig No.5 & 6 and all other parameter are also consider while making the frame design such as better capacity and specification are taken for standard such as

20000mah battery and for propeller are use in quad/octocopter are 14inch diameter with using standard DJI motors are used, all other remaining parameters of electronic such as ESC, flight control, GPS, transmitter /receiver, Camera & Gimbal.

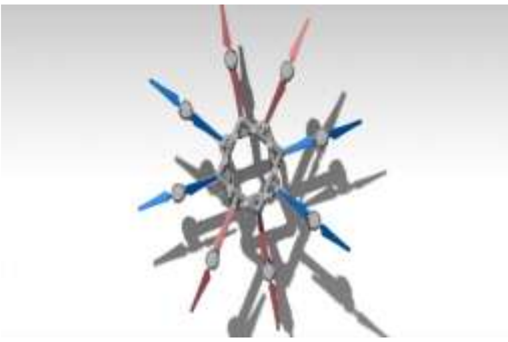

Fig -5: Octocopter top view

Fig -6: Octocopter side view

payload is consider as 7-10 Kg for the octocopter drone frame, and propellers are 4 clockwise and 4 anti-clockwise propellers are used by color combination red and blue in isometric diagram of octocopter.

Fig -7: Octocopter isometric view

Table No. 1 Approximately Cost& weight of Octocopter drone

Sr No.	Component Name	Quantity	Per Price Rs	Total Price in Rs	Wt in gm
1	Electronic Speed Controller	8	446	3568	184
2	Brushless motor	8	749	5992	280
3	Lithium polymer battery	4	4389	17556	1440
4	14 inch Propellers	8	446	3568	360
5	Ardupilot APM 2.8 Flight Controller Board	1	2627	2627	43
6	(6061-T6SP40-100-133) Seamless Aluminum Pipe	2meter	1250 /m	2500	700
7	3D Printed Joints	16	560	4500	200
8	GPS, transmission System and Other			17000	100
	Approximately Total Cost			57311	3207

4.1 Flight Time Calculation

Quadcopter Flight Times = (Battery Capacity x Battery Discharge /Average Amp Draw) x 60

Quadcopter Flight Times = (5200 × 4 1000) × (80% 30amps) x 60mins = 165.9mins

Obviously this quadcopter battery calculator is a very simplistic calculator base on steady hover. For aerial photography work or FPV flying which the motors will have to spin faster, and thus pull more current. This higher current draw will reduce flight time and your flight times will degrade dramatically with about 75% or up to 50% of the calculated quad copter flight time.

So, 50% is considering as per safety so we get 165.9mins/2= 82.95mins and for Octocopter Drone 82.95mins/2= 41.4mins (self-weight & without Payload capacity of electronic system) While considering the self-weight of system is 3207gm and payload 4000gm is taken we get by analytical iteration calculation chart of Flight time Vs. Payload for Drone hence practically we get 22.5mins flight time with self-weight of the system and 9mins flight time at maximum payload capacity.

For checking the above calculation we have compared with xcopterCalc - Multicopter Calculator form Internet putting all above parameters and conditions for Octocopter drone in that calculator we got results as below shown.

Fig -8: Compare with xcopterCalc - Multicopter Calculator

5. ANALYSIS

The static analysis is done in ANSYS19.2 software for importing the CAD file we selected STEP file format and open the geometry is shown below

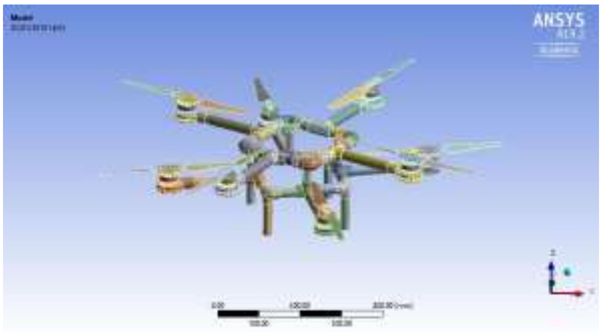

Fig -9: Import STEP files of Octocopter drone

6. PER-PROCESSING

In the pre-processing the meshing in done on the default module in which software decide the mesh the geometry and gives results, in this we get number of nodes 561996 and number of element 282576 in Coarse mode. It is shown below figure

Fig -10: Meshing model of Octo copter drone

In the setup mode we decide the fix support and gives loading conditions and apply the forces along the boundary conditions of the setup and we are trying to get maximum safety result according to the maximum loading condition and applied maximum forces in all direction for the static analysis is shown below

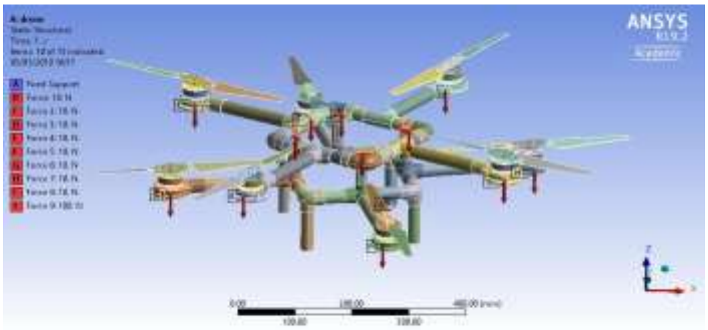

Fig -11: Static Setup of Octocopter drone

7. RESULT

The results are gets after solving the all pre-processing work in which all conditions and parameters are set in the software and find out the required results such as deformation, stress and safety factor of the frame is analyzed and shown below all results.

7.1 Total deformation

In the loading conditions of all the forces we get 0.05mm deformation to the central of the frame and 0.83 to the edge of the motor as below shown in the figure.

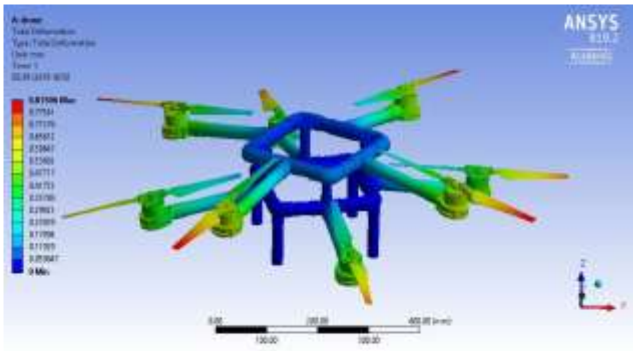

Fig -12: Total Deformation of Octocopter drone frame

7.2 Maximum principal stress

In the loading conditions of all the forces we get 367Mpa maximum principal stress to the central of the frame and 36Mpa to the edge of the motor as below shown in the figure.

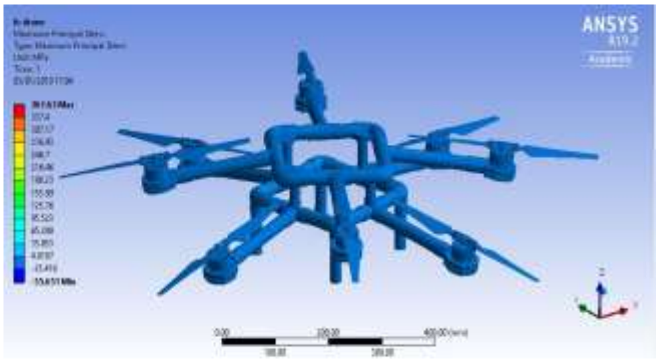

Fig -13: Max. Principal Stress of Octocopter drone frame

7.3 Fluid flow analysis of Propellers

The velocity contours which create low velocity region at lower side of the fuselage and higher velocity, acceleration region at the upper side of the fuselage and according to principle of Bernoulli's upper surface will gain low pressure and lower surface will gain higher pressure. Hence value of coefficient of lift will increase and coefficient of drag will also increase but the increasing in drag is low compare to increasing in lift force.

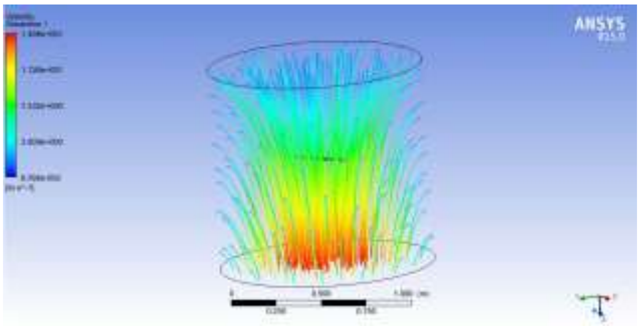

Fig -14: Velocity Stream line of Octocopter drone Propeller

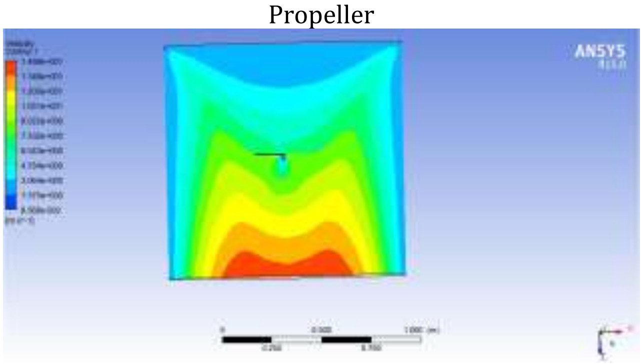

Fig -15: Velocity Contour of Octocopter drone Propeller

8. CONCLUSIONS

In this study, the focus was on the use of proposed drone for industrial works more specifically for multi-purpose application as per the customer requirement. The design considerations were explicitly for generic drone uses such as light and heavy duty applications, entertainment, courier services etc. I have tried to keep design as simple as possible so that manufacturing processes used will not cost much. The proposed drone is user friendly and also easy to understand.

In this paper I have tried to reduce (approximately 30 %) the manufacturing cost of the frame. To use it for more heavy applications, I have combined two quad copters in one octocopter. An acceptable safety factor of 3 was observed during static analysis of designed octocopter. This safety factor is very much acceptable considering its manufacturability and the applications for which it was initially targeted

Propeller Design is carried out by importing the airfoil section onto the datum planes. Using the ANSYS workbench software, analysis of the Propeller and Frame were carried out and the results obtained were within the limits. For analyzing the propeller structure ANSYS Workbench is the most efficient software. To achieve optimal aerodynamic performance, the only option would be to design a propeller to suit the specific application of high thrust upward propulsion and can improve the current flight time of Octocopter drone for the heavy applications. After checking the propellers analysis and frame we have to check correlation of whole system and effect of air pressure while lifting the Octocopter drone.

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