Design of A Quad Copter and Fabrication

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Abstract- Quadcopters are the unmanned air vehicles and these are playing a predominant role in different areas like surveillance, military operations, fire sensing and some important areas having many complexities. To deal quadcopter weight is the main constrain which is important and play a predominant role in these un manned vehicles. The main objective of the paper is to deal with the design of the "Quad copter" the regular design of the quadcopter is modified and the static analysis is done on frame to sustain the loads generated in these vehicles and concluded that small deformation occurred on the center plates are safe and within the limit.

Keywords – Quadcopter, Unmanned air vehicle, RBE3,RBE2.

I. INTRODUCTION

A Quadcopter is a quadrotor helicopter which is having the four motors, but it is entirely different where as the lift force is produced by the four motors. The similarity exist between the helicopter and the quadcopter is the vertical takeoff and landing. These quadcopters are controlled by using a remote control for that reason they can be used in three area such as military to do spying on enemy camps, to avoid loss of man power these are unmanned aerial vehicles[1] ; searching in place where the human cannot serve and recently in transportation of goods such as medicines etc. These quadcopter are classified into two types micro air vehicle and mini air vehicles this classification mainly depending on the size and weight of the quadcopter. Each rotor has its own significance in creating thrust, torque and direction. The propellers which create the thrust to the Quadcopter is not alike two of them are clock wise act as pullers and other two are anti clockwise act as pushers. As consequence , the resulting torque is 'Zero'. In order to define an aircraft’s orientation (or attitude) around its center of mass, aerospace engineers usually define three dynamic parameters, the angles of yaw, pitch and roll as shown in the figure1 and by varying the speed of the motors the direction of the quad varies as shown in the figure2

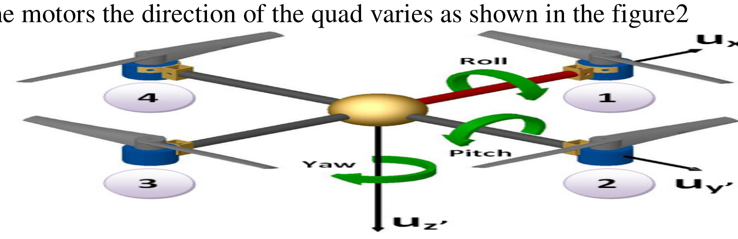

Figure1 Yaw, pitch and roll rotations of a common quadrotor

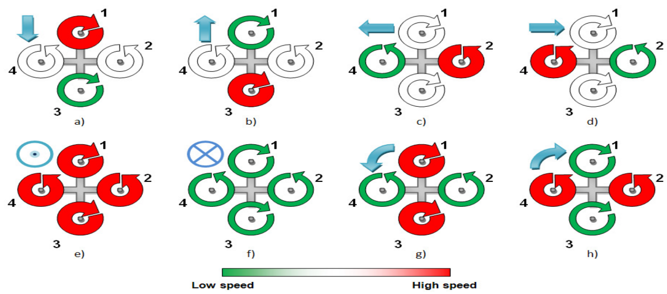

Figure2 Illustration of the various movements of a quad rotor

II. MOTIVATION

These Quad copters are having so many applications due

- No gearing required between the motor and the rotor
- No variable propeller pitch is required for alternating quadrotor
- Minimal mechanical complexity
- Low maintenance
- Less loads on the center plates
- Payload augmentation

III. LITERATURE REVIEW

Quadcopters had an incredible evolution in 21st century. Universities, students and researchers continuously work to introduce more robust controllers and modeling techniques, so that they can provide detailed and accurate representations of real-life quadrotors. This section introduces some of the work presented in recent years. Hardik Modh [1] published the work on frame design and they had evaluated the theoretical, analysis and testing results and they compared the results for different cross sections. Pounds et al. deals about fundamental dynamics analysis and control approaches through the design of a large-size quadcopter with total weight of 4kg and capable of lifting a 1kg payload which was deemed necessary for the computers and sensors of the time [2;3]. Swee King Phang, Kun Li, Kok Hwa Yu, Ben M. Chen and Tong Heng Lee[4] deals the systematic design and construction of the small quadcopter they had done analysis on the frame by taking the thickness and different shapes of the frame. Antonio DiCesar[5] had proposed a frame in which they just concentrated on the autonomous flight and reduction in the weight. Kalpesh N. Shah [6] work on the quad copter arm with different cross sections

IV. QUADCOPTER CAD MODEL AND ELECTRONICS USED

The CAD model prepared for the construction of the Quadcopter is as shown figure3 and the total assembly of the Quad copter in figure4

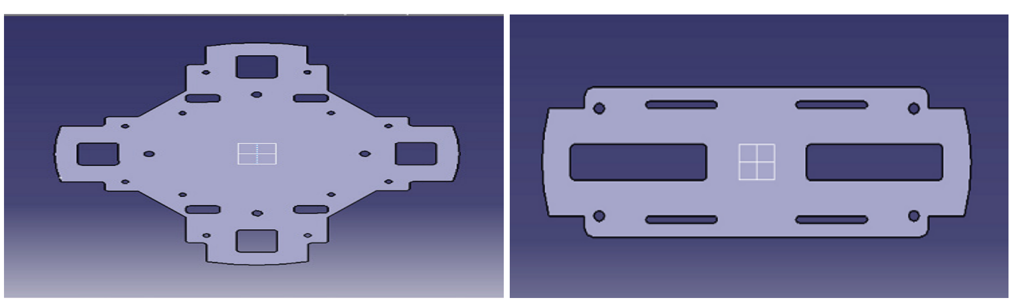

Figure3 CAD model of Top and Bottom Plates

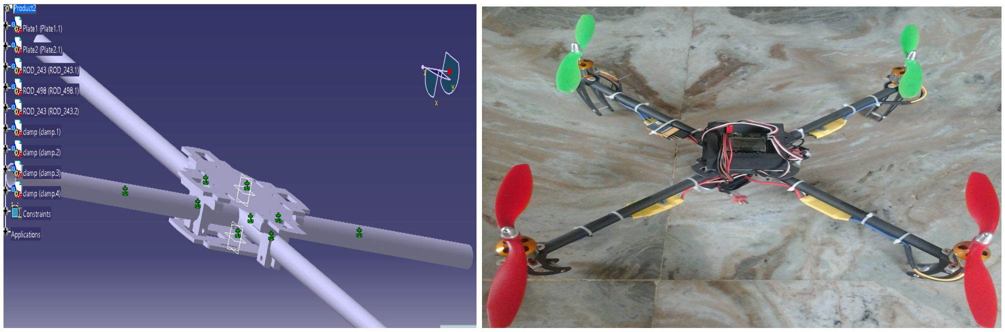

Figure4 CAD and Fabricated Model of the Quadcopter

a) *Brushless Motor:*Brushless motors give the 1:1 speed ratio. In quad copter four rotors with brushless motors are used to get high efficiency for less power and low weight. Motor performances and 1200kv brushless motor used for this paper is as shown in the fig(5).performance graph is taken form drive calculator software

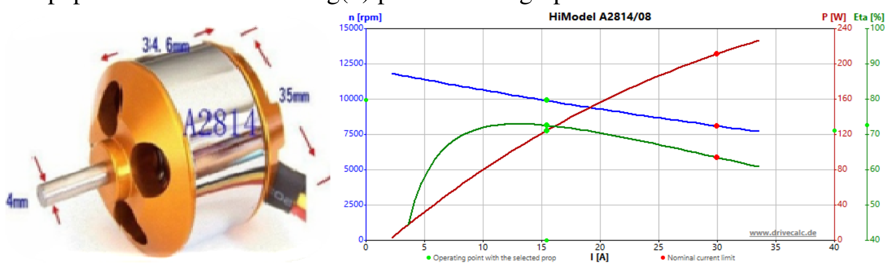

Figure5 Brushless motor and Performance curve of brushless motor

b) Propeller: Propellers are used to generate the thrust for the quad copter hover or lift. These are in different variants which are classified based on their diameter and pitch by which they travel. To create maximum thrust we use to have two "standard rotation" and two "right hand rotation" propellers. The propeller size 8045 is used which are shown in the fig(6)

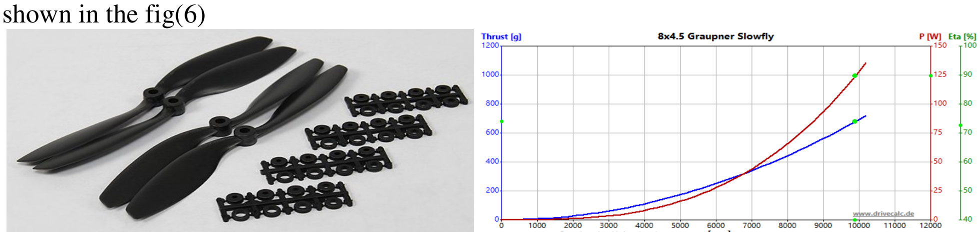

Figure6 propeller set and Performance curve of propeller 8045

c) Electronic Speed Controllers: Electronic speed control convert the available 2phase battery current to the 3-phase power and also regulates the speed of brushless motor by taking the signal from the control board.

d) Control Board: Control board is the main system which is connected to the receiver and Electronic Speed Controls which is pre loaded with different set option from single copter to octocopter. This board is used to different operations performed by the quad copter like roll, pitch and yaw. This board is suitable for the 4channel transmitter and one auxiliary port to control such as sensors etc.

e) Receiver And Remote Control: These Quad rotors are controlled by using a 2.4Ghz transmitter and the receiver has been connected to control board

f)Lithium Polymer Battery: It is a constraint of weight so we use a lithium polymer battery in which hi power due to that reason we use these batteries for these micro air vehicles. these are available in different variants from 1000mah to 10000mah.

g) Servo Leads: Servo leads are the connection cables between the receiver - control board and between Electronic speed control - control board these are having three leads which is connect the signal, power(+) and earth(-) connection

V. FEM MODEL OF QUADCOPTER

The CAD model is prepared and converted to the IGES or STP format and imported into a pre processor PATRAN to create the FEM model. Depending on the Swee King Phang [2] the CAD model is meshed with respective to their degrees of freedom they suppose to have the meshing structure. As shown in figure7 and8

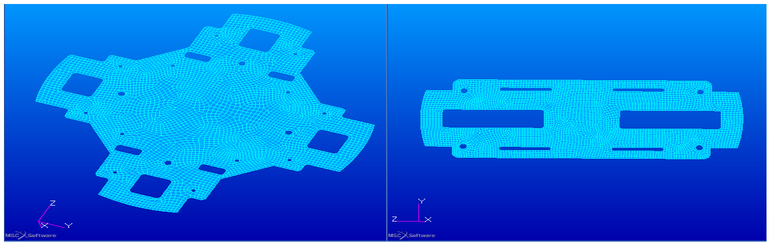

Figure7 2D shell mesh on TOP and BOTTOM PLATES

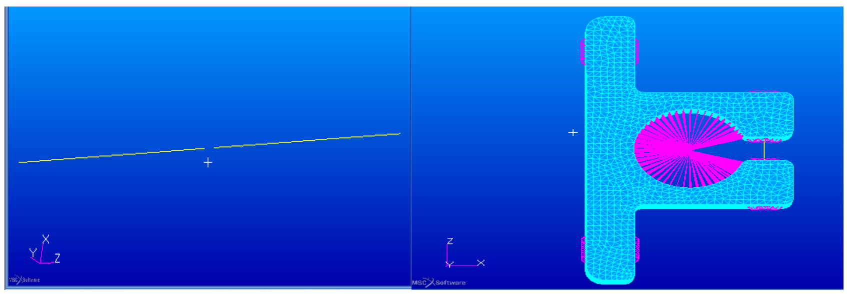

Figure8 C Beam meshed rods and solid meshed clamp

The connection in assembly are connected by using the different connectors as shown in the fig9. they are C Bush, RBE3, RBE2. C BUSH is the replacement for the fasteners the stiffness coefficients in this assembly is only axial stiffness

$$\boxed{K_1 = E*A / L}$$

Here E: young's modulus; A:Area of fastener; L:Length

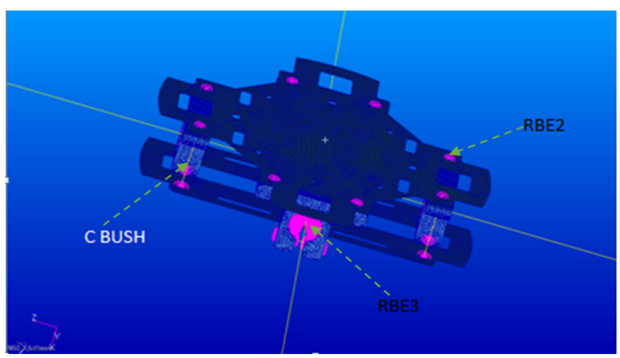

Figure9 Fully meshed Assembly

A. *Material properties*

In this assembly the major parts are done by using the carbon fiber which is cured in EPOXY at 1200 C. The carbon fiber used in this process is the Fabric, for clamp is Aluminum is used. The following Table(1) represent material properties of carbon fiber and aluminum.

Table1 Carbon fiber and Al properties

Property	Carbon fiber	Al
Young's modulus(GPa)	70	70

Poisson's ratio	0.1	0.33
Ultimate tensile strength(MPa)	600	550
Ultimate compressive strength(MPa)	570	469
Density(gram/cc)	1.6	2.86

The resultant forces are transferred from the propeller to rod ,rod to clamp and the clamp to the top and bottom plates.

For testing the static strength the forces applied on the Rod are the thrust, centrifugal force and the moment created by the propeller.

Centrifugal force(Fc) : $m\omega^2 r$ Newton

Here m:mass of propeller Kg

r:Radius of the propellers m

ω: Angular speed $(2\prod N/60)$ rad/sec

N:speed of the propeller rotating(rpm)

Moment: Fc*(Perpendicular distance b/w prop centre and rod surface) in Newton

Thrust force(Fv): created by the propeller in Newton

B. CALCULATIONS

Centrifugal force(Fc) : $m\, r\omega^2$

$:010^* .1016^*(2^*\prod^*10000/60)^2$

: 11.319KN

Moment (M):11316*.05

:569N-m

Thrust (Fv):6.54N

The forces calculated in the above is applied on the respective arm as shown in the fig(10)

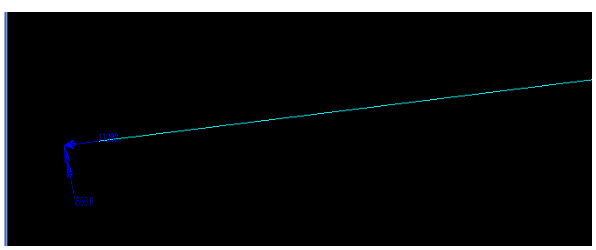

Figure10 Loading of the rod at end

Application of loads for the clamp and plate are shown in the fig.11 and the loads are tabulated in table3

Table 3 Forces applied

Force applied	Fx	Fy	Fz	Mx	My	Mz
On clamp	8.19E+00	-1.14E04	0.00	2.6E-14	1.8E-17	-1.5E+02
On Top &bottom plate	3.7E+00	3.16E+01	-1.2E-02	-2.7E-17	1.1E-05	3.23E-02

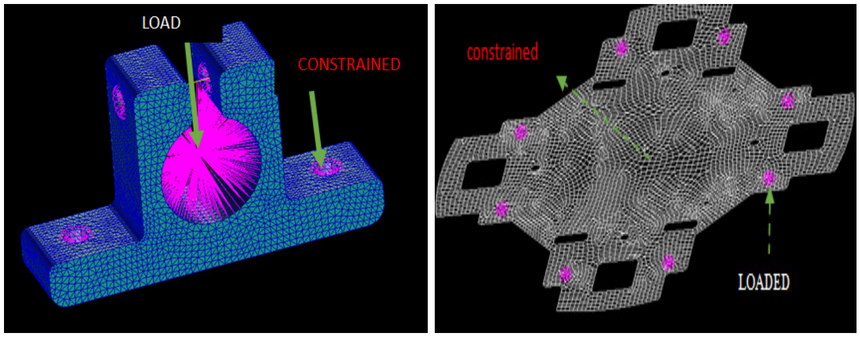

Figure11 Loading and constraints Of Clamp And Top Plate

VI. RESULTS

The obtained resultants of von mises and principal stress are as tabulated in the table(4) and result plots for the both von mises and the principle stress are as shown in fig(12-14)

Table4 Comparison of ultimate stress to the obtained

PART	Ultimate stress	Von Mises obtained	Principal stress obtained
ARM	600MPa	330MPa	330MPa
Clamp	550MPa	547MPa	532MPa
Top & Bottom Plate	600 MPa	3.24MPa	3.69MPa

Stress plots for the Quadcopter components

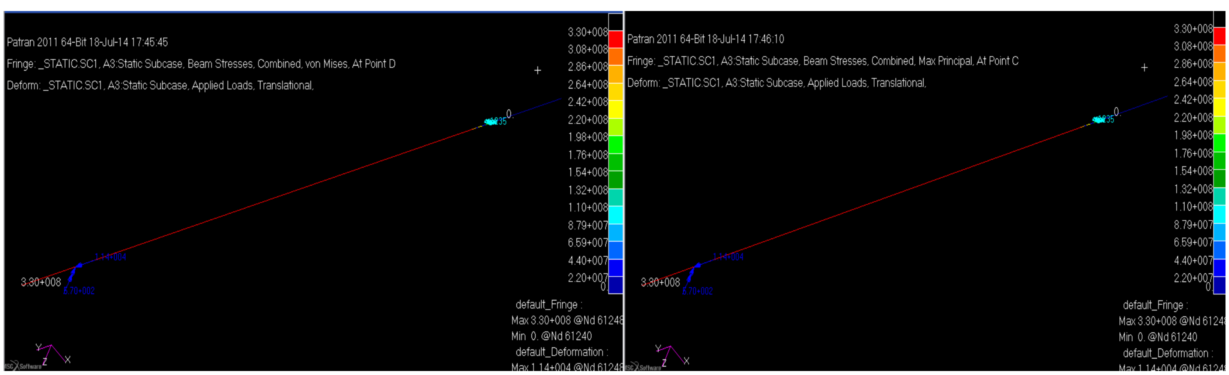

Figure12Von Mises and principal stress plot for the Arm

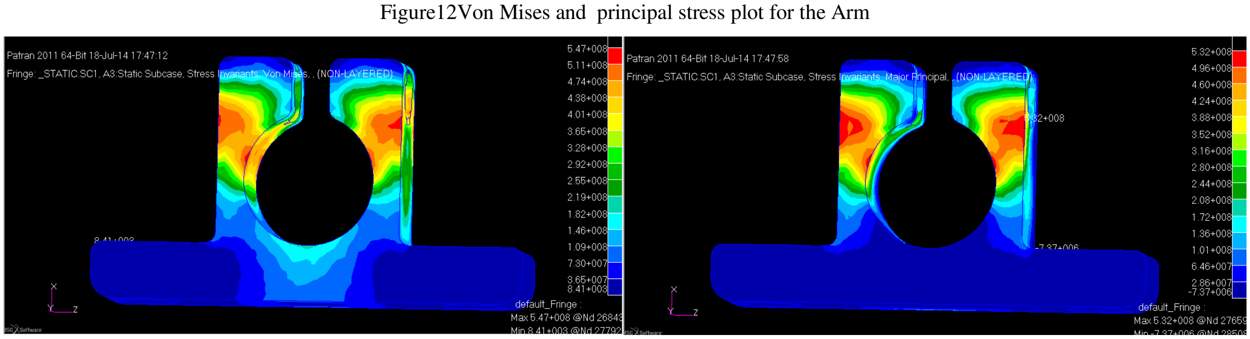

Figure13 Von Mises and principal stress plot for the Clamp

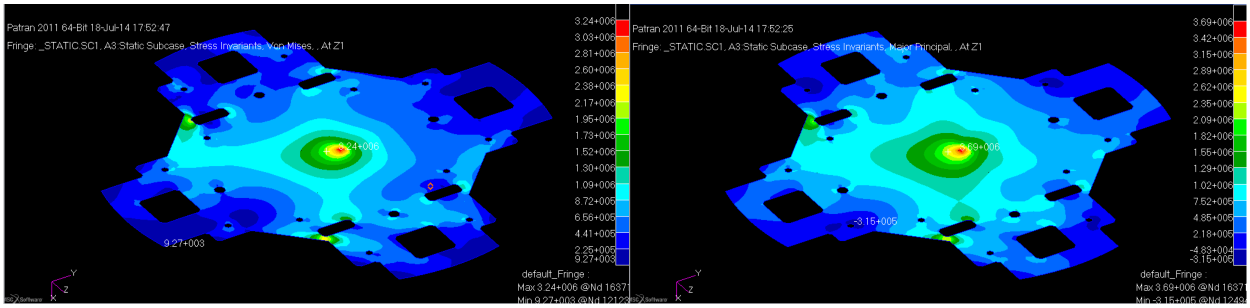

Figure14 Von Mises and principal stress plot for the TOP PLATE

VII. CONCLUSIONS

The maximum stress obtained in the all the parts are below the ultimate strength we conclude that the frame is statically sustained and also It was found that very low loads are obtained in the top plate. By that by changing the shape of the base plate the performance of the Quad copter cannot be that there is a reduction 50% in the weight of the base plate so that the power consumption is reduced.

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