# Design and Analysis of Quad Copter Frame and Propeller

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*Abstract*— Quadcopters generally use two pairs of identical fixed pitched propellers; two clockwise (CW) and two counterclockwise (CCW). These use independent variation of the speed of each rotor to achieve control. By changing the speed of each rotor it is possible to specifically generate a desired total thrust; to locate for the centre of thrust both laterally and longitudinally; and to create a desired total torque, or turning force. A quadcopter, also called a quadrotor helicopter or quadrotor, is a multirotor helicopter that is lifted and propelled by four rotors. Battery was used as a power source to run the motors, thereby propellers. Modeling and Analysis are the two important unavoidable steps in manufacturing any component or structure. In this paper we were concentrating on design and analysis of a Quadcopter frame and propeller. The modeling was done by a software, named PTC Creo while the analysis was done using ANSYS. The results obtained were compared with the various properties of frame materials which tell us whether the design made was safe or not.

***Key words:*** Quadcoptor, A36 Steel, PTC Creo and ANSYS

## I. INTRODUCTION

### A. Quadcopter

The basicdynamical model of the quadcopter is the starting point for all of the studies but more complex aerodynamic properties has been introduced by Hoffman and Haung.

A quad rotor, also called a quad rotor helicopter or quad copter, is a multicopter that is lifted and propelled by four rotors.

Quad rotors are classified as rotor copter, as opposed to fixed-wing aircraft, because their lift is generated by a set of revolving narrow-chord airfoils. Unlike most helicopters, quad rotors generally use symmetrically pitched blades; these can be adjusted as a group, a property known as 'collective', but not individually based upon the blade's position in the rotor

Quadcopter unmanned aerial vehicles are used for surveillance and reconnaissance by military and law enforcement agencies, as well as search and rescue missions in urban environments.

Quadcopters are a useful tool for university researchers to test and evaluate new ideas in a number of different fields, including flight control theory, navigation, real time systems, and robotics.

### B. Quadcopter Components

The main mechanical components needed for construction are the frame, propellers (either fixed-pitch or variable-pitch), and the electric motors. For best performance and simplest control algorithms, the motors and propellers should be placed equidistant. Recently, carbon fiber composites have become popular due to their light weight and structural stiffness.

The electrical components needed to construct a working quad copter are similar to those needed for a modern RC helicopter. They are the electronic speed control module, on-board computer or controller board, and battery. Typically, a hobby transmitter is also used to allow for human input.

## II. ABOUT PTC CREO

PTC Creo, formerly known as Pro/ENGINEER, is a 3D CAD, CAM, CAE, and associative solid modelling app. It is one of a suite of 10 collaborative applications that provide solid modelling,

Creo Elements/Pro offers a range of tools to enable the generation of a complete digital representation of the product being designed. In addition to the general geometry tools there is also the ability to generate geometry of other integrated design disciplines such as industrial and standard pipe work and complete wiring definitions. Tools are also available to support collaborative development.

## III. ABOUT ANSYS

The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. With bi-directional CAD connectivity, powerful highly-automated meshing, project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation Driven Product Development.

Ansys software simulates and analyzes movement, fatigue, fractures, fluid flow, temperature distribution, electromagnetic efficiency and other effects over time.

## IV. PRO/E DESIGNS

### A. Quadcopter Frame

In designing quadcopter's body frame, one must regard the total weight which will be borne by quadcopter such as the weight of electronic, frame, landing gear, rotor and sensor. For this model, the size was determined firstly so that the type of rotor and propeller used can be calculated in terms of quadcopter ability to carry weight. As seen in Fig. 4.1., the dimension of quadcopter is 560 (mm) (length) x 560 (mm) (width). To obtain the lightest weight possible yet with decent rigidity so as to make it possible to carry weight and fly stable, a perforation was made into the body frame while keeping in mind the symmetry and the centroid of the frame. Material used for Quadcopter frame is Structural steel ASTM (A36 steel).

 

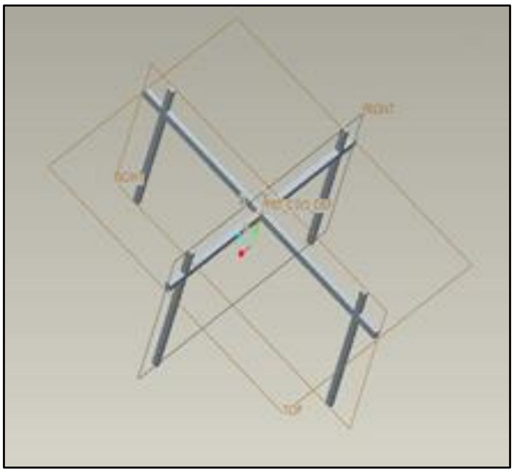

Fig. 4.1: Quadcopter Frame

### *B. Propeller*

In body frame design, the distances between rotors determine the propeller's size. The propeller's size and its angular velocity will determine the magnitude of airflow and thrust produced. Airflow variations cause unexpected aerodynamic forces through changes in thrust conditions and un-modeled blade-flapping dynamics. The opposite pair of the propeller will rotate in the same direction, as shown in Fig. 3. There is a limitation on the maximum size of the propeller that can be used based on the maximum torque of rotor and the magnitude of airflow produced by each rotor. To attain quadcopter flight stability with respect to space area, it is better to design the body frame and have control surface which, together with the aerodynamic, shapes of the rest of the airframe. The result is in the form of stability characteristics. This can be done by minimizing the disturbance from air turbulence and also from natural occurrences. Material used for Quadcopter propeller is Mild steel 1090.

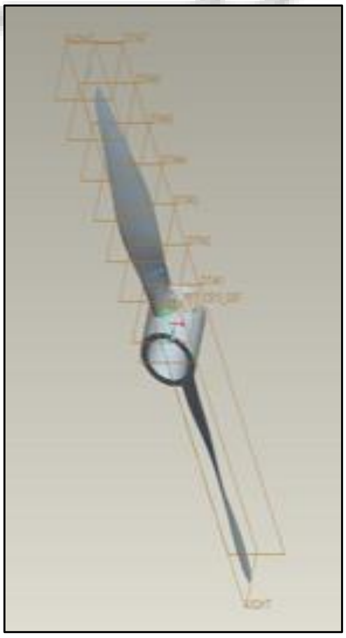

Fig. 4.2: Propeller

## V. ANSYS RESULTS

### *A. Analysis of Quadcopter Frame:*

Quad copter frame is made up of analysed by using Structural Analysis. Load applied is 500N i.e the approximate load for lifting a person using a quadcopter.

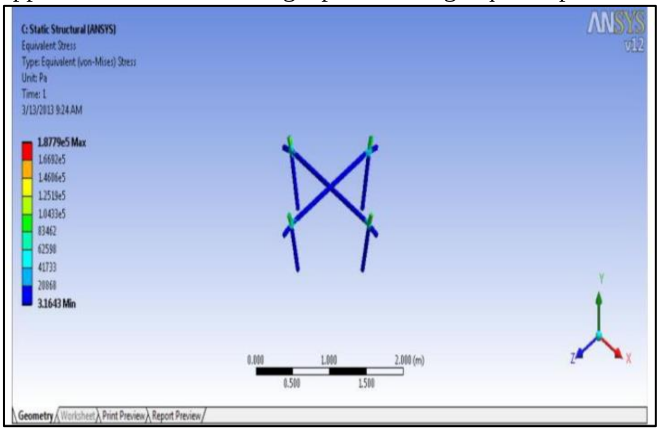


Fig. 5.1: Analysis of Quadcopter Frame

A36 steel has a density of 7,800 kg/m$^3$ (0.28 lb/cu in). Young's modulus for A36 steel is 200 GPa (29,000,000 psi). A36 steel has a Poisson's ratio of 0.26, and a shear modulus of 75 GPa (10,900,000 psi). A36 steel in plates, bars, and shapes with a thickness of less than 8 in (203 mm) has a minimum yield strength of 36,000 psi (250 MPa) and ultimate tensile strength of 58,000–80,000 psi (400–550 MPa). Plates thicker than 8 in have a 32,000 psi (220 MPa) yield strength and the same ultimate tensile strength of 58,000–80,000 psi (400–550 MPa).The electrical resistance of A36 is 0.142 μΩm at 20 °C. A36 bars and shapes maintain their ultimate strength up to 650 °F (343 °C). Afterward, the minimum strength drops off from 58,000 psi (400 MPa): 54,000 psi (370 MPa) at 700 °F (371 °C); 45,000 psi (310 MPa) at 750 °F (399 °C); 37,000 psi (260 MPa) at 800 °F (427 °C).

The Ultimate Tensile Strength of a Structural Steel is 400-550 MPa. The Ultimate Tensile Strength that is obtained for designed quad copter frame is 449 Mpa. The other parameters obtained for the quad copter are also within the limits. Hence the quadcopter frame structure is safe.

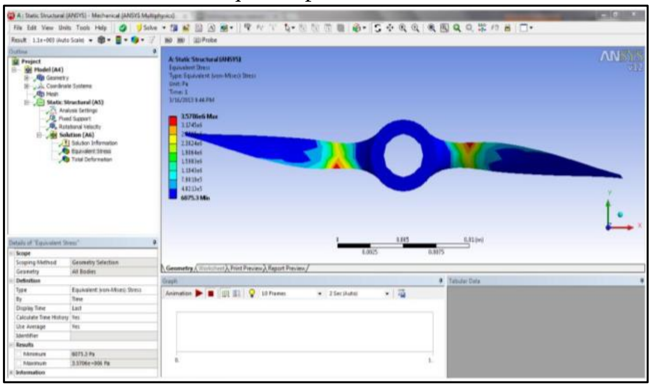

Fig. 5.2: Analysis of Propeller

### *B. Analysis of Propeller:*

The quad copter propeller is also analysed using the structural analysis. For the analysis of Propeller it is given a rotational velocity of 10000 rpm and the analysis is performed.

 

The Ultimate Tensile Strength of Mild Steel is 841 MPa and The Ultimate Tensile Strength that is obtained is 746 MPa. Hence the structure is safe.

## VI. CONCLUSION

The propeller is designed using the airfoil section S7075. By importing the airfoil section onto the datum planes design is carried out. Analysis of the Propeller and Frame are carried out using the Ansys workbench software and the results we have obtained are within the limits.

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