DESIGN AND ANALYSIS OF UNMANNED AERIAL VEHICLE (UAV) USING SOLIDWORKS 2016 EDITION

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Abstract - *Unmanned Aerial Vehicles nowadays are being widely employed in Army rescue operations, Dam Surveillances, Firefighting, Precision farming, Road maintenance, Tracking Volcanic Activities, Medical Services, Area Mapping, Sporting Activities, Temperature & Humidity Monitoring, Particulate Matter Content monitoring, Wildlife Monitoring as well as Film Making Industries because of their versatility, small size, reliability, cost effectiveness and high maneuverability. Stage, research have been made on quadcopter by worldwide researchers. This paper describes the study of the each components of the Quadcopter, Static analysis of the Quadcopter parts' CAD model like Spider Arm & Suspension bottom in Simulation Software using Finite Element Method and Quadcopters' movement mechanisms. This means going through the process of researching previous models, performing calculations, design/ CAD model using 3-D Modelling Software (SOLIDWORKS 2016 x64 Edition SP02) then purchasing individual parts, testing the prototype and designing the final product. Experimental results show the improvements of the stability of Quadcopter. Our news and features will cover developments in quadcopter technologies, innovative uses for quadcopter and how quadcopter use will impact society. Applications of Drones are not limited to the military world only rather they are serving a big part of economy with advanced mechanisms and impressive capabilities. The growing interests of users in the drone technology have developed new fields of application for it. Presently, drones are working in so many areas and with continuous advancements in technologies these machines are going to be more robust and useful in coming future too. They are now able to carry huge payloads and can serve users with longer flight times as compared to their older versions. With growing technology, many new sensors are being added to drones so that their operation can be highly optimized and they can work for dedicated applications with high performance. Drones are now working in all fields where humanity uses to operate; you can find them in agriculture industry as well as in the world of internet.*

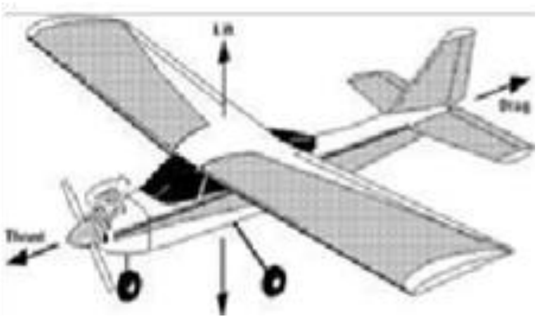
Key Words*: *Quadcopter, balancing, drone, multi-rotor, CAD, Static Simulation.

1. INTRODUCTION

Drone is an acronym for Dynamic Remotely Operated Navigation Equipment. A Drone may be a Bicopter, Tricopter(Y3, T3), Quadcopter(X4, Y4, V-Tail, A-Tail) or Hexacopter(Y6), it is basically a multirotor helicopter that is lifted and propelled by two, three, four or six rotors respectively. Most of the helicopters, Quadcopters use two sets of identical fixed pitched propellers; two clockwise (CW) and two counter-clockwise (CCW). Quadcopters use variation of rotor RPMs to manipulate and control torque and lift. Control over quadcopters' motion is achieved by altering the rotation rate of one or more rotor discs, thereby changing its torque load and thrust/lift characteristics by using a microcontroller. A Quadcopter is basically a mini-helicopter with four rotors, and is also known as Quadrotor. Because of its unique design in comparison to traditional helicopters, it allows a more stable platform, making Quadcopters ideal for tasks such as surveillance and aerial photography. And it is also getting very popular in UAV research in recent years

Quadcopter, is also known as **Unmanned Aerial Vehicle** (UAVs), as they do not have any human pilot onboard, and are either controlled by a person remotely or autonomously using a computer program. It is a stealth craft becoming increasingly popular, Drones have become Scientists' eyes and ears by surveying grounds for archaeological site, illegal hunting signs and crop damage, and even zipping inside hurricanes to study the wild storms.

Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of revolving narrow-chord airfoils. To give you a better understanding of what a Quadcopter contains I will now go through some of the parts it contains.



Weight

Fig -1: Forces acting on a flying plane

2. LITERATURE REVIEW

Review stage research have been made on quadcopter by worldwide researchers. The use of Unmanned Aerial vehicles (UAVs) to support humanitarian actions has grown since 2001, after terrorist attack of 09/2011.It is used for tracking active volcano or active volcanic zone in order to minimize the effect on mankind. UAVs are valuable tools due to their flexibility, safety, ease of operation, there is also reduction in manpower or less human dependency, which facilitates its' use in disaster situations. This paper provides a systematic literature review on the applications of UAVs in humanitarian. And it is helping us to understand what can be explored in this area. After two eruptions in the span of a month, the public is suddenly paying attention to volcanoes. But volcanologists have been watching them for years, and now, a small group is taking volcano monitoring to new heights with the help of drones. Drones, also known as unmanned aircraft vehicle (UAV), can help volcanologists keep closer tabs on the dangerous geologic features.

3. QUADCOPTER MOVEMENT MECHANISM

Quadcopter can described as a mini vehicle with four propellers attached to rotor located at the cross frame. This aim for fixed pitch rotors are used to control the motion of the quadcopter. The speeds of these four rotors are independent. By independent, pitch, roll and yaw attitude of the quadcopter can be control easily. Pitch, roll and yaw attitude off Quadcopter are shown in Figure

Yaw Motion (W): Rotation around the vertical axis is called Yaw. Rudder is needed to controls Yaw (Left and Right).

Pitch Motion (o): Rotation around the side-to-side axis is called Pitch i.e., Moving Upside and Downside about horizontal axis. The Elevator controls the Pitch.

Roll Motion (4'): Rotation around the front-to-back axis is called **Roll** i.e., tilting about the axis.The Ailerons controls Roll axis (Left and Right).

Take-off and landing motion mechanism Take-off (landing) motion is control by increasing (decreasing) speed of four rotors simultaneously which means changing the vertical motion. Take-off is movement of Quadcopter that lift up from ground to hover position and landing position is vice versa of take-off position.

Forward and backward motion Forward motion is control by increasing speed of rear rotor. Backward motion is control by decreasing speed of front rotor. Decreasing (increasing) rear (front) rotor speed simultaneously will affect the pitch angle of the Quadcopter.

Left and right motion for left and right motion, it can control by changing the yaw angle of Quadcopter. Yaw angle can control by increasing (decreasing) anticlockwise rotors speed while decreasing (increasing) clockwise rotor speed.

Fig -2: Quadcopter Movement Mechanism

Hovering or static position: The hovering or static position of Quadcopter is done by two pairs of rotors are rotating in clockwise and anticlockwise respectively with same speed. By two rotors rotating in clockwise and anticlockwise position, the total sum of reaction torque is zero and this allowed Quadcopter in hovering position.

3.1 COMPONENTS

Flight Controller It is the 'brain' of the Quadcopter. This is houses the sensors such as gyroscopes and accelerometers that determine how fast each of the Quadcopter's motors spin. The Flight control boards range are from simple to highly complex. This Flight controller KK 2.1.5 is the latest one and program is pre-installed in it.

DC Brushless Motor: It is a high power motor with excellent efficiency. The purpose of motors is to spin the propellers. Brushless DC motors provide the necessary thrust to propel the craft. We use 1000 **KV** motors. Motors are rated by kilovolts, and the higher the KV rating, the faster the motor spins at a constant voltage.

Propellers we are using two types of propeller Pushers and Pullers: Pushers: Pushers give thrust when they are rotated in clockwise direction.

Pullers: Pullers give thrust when they are rotated in anticlockwise direction. The propellers come in different diameters and pitches (tilting effect). The size of propellers given as 10*4.5.

Electronic Speed Controller (ESC): The electronic speed controller controls the speed of the motor or tells the motors how fast to spin at a given time. For a quadcopter, 4 ESCs are needed, one connected to each motor. The ESCs are then connected directly to the battery through either a wiring harness or power distribution board. Electronic Speed Controller (ESC) is an electronic circuit to vary the speed, direction and possible to act as a dynamic brake, of a brushless Motor. The maximum current flowing in the ESC is in between the range 30-40 ampere.

Battery (LiPo): Lithium polymer batteries (LiPo) are most popular for powering remote control aircraft due to its light weight, energy density, longer run times and ability to be recharged. We selected zippy 4000mah, 11.1 V, 3 cell, 20 C battery.

Transmitter & Receiver: This transmitter can be used on any of your planes and with a LCD display screen you can now program the radio at the field and no more to carry your laptop to the field to change any high end radio but at a fraction of cost. Some of the unique features of this radio are Interchangeable from mode 1 to mode 2 with the use of a Slider at the back of the radio. Remote range test (you don't have to walk a kilometer to find out the range of your receiver). Variable transmission power (for indoor and outdoor).

COMPONENT ANALYSIS:

- **SPIDER ARM (**STATIC ANALYSIS**)**

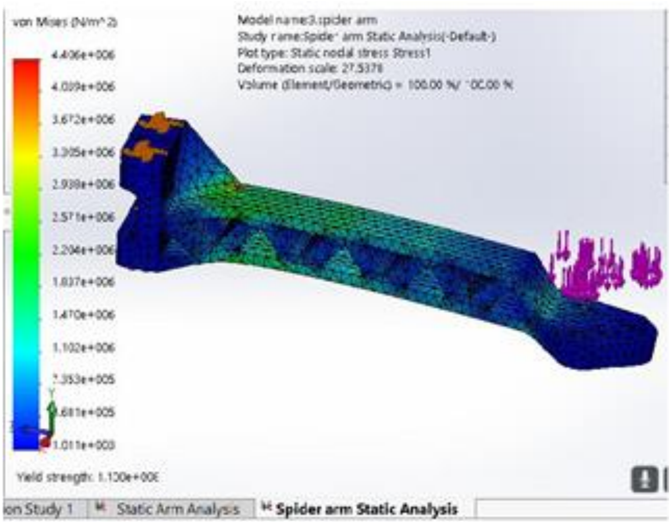


Fig - 3.1.1.a: Von Mises Stress Analysis

(max. value=4.406MPa)

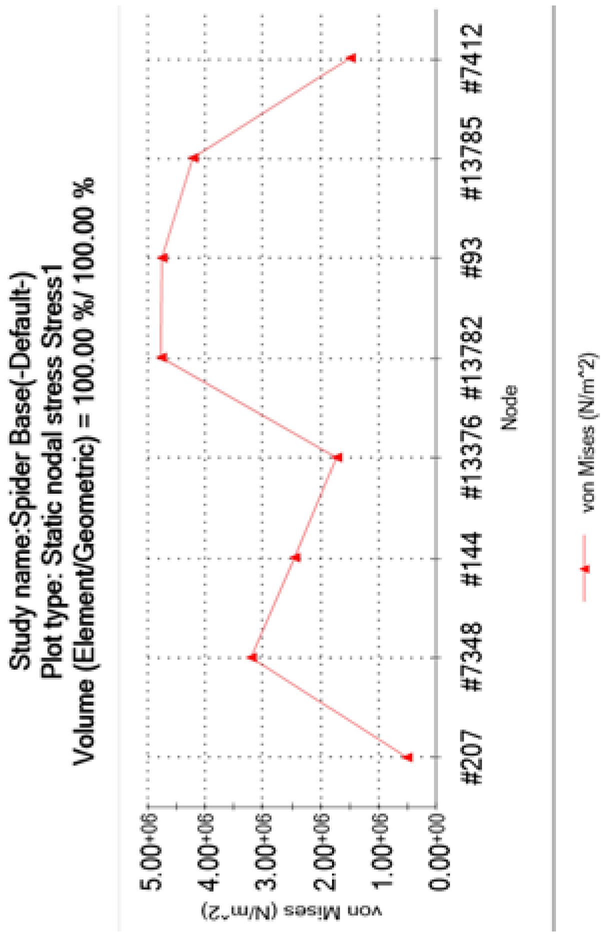


Chart -3.1.1.1: Von Mises Stress (Spider Arm)

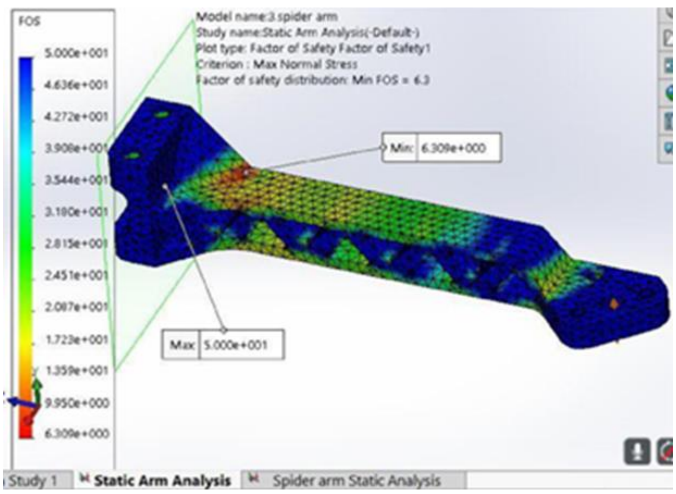


Fig - 3.1.1.b: Factor of Safety (min. value=6.3)

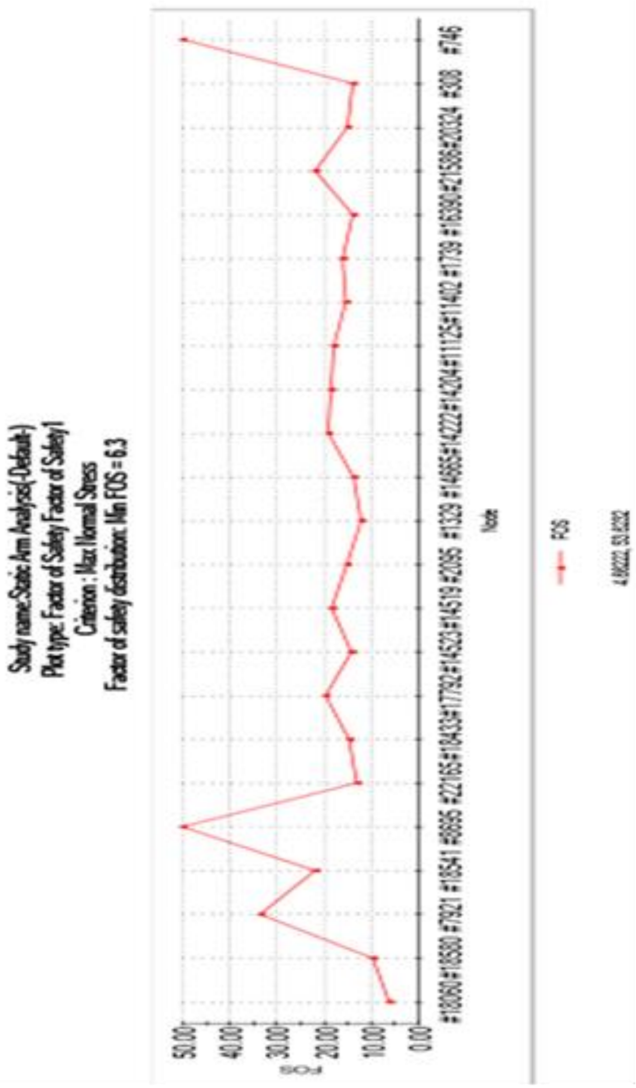


Chart -3.1.1.2: Factor of Safety (Spider Arm)

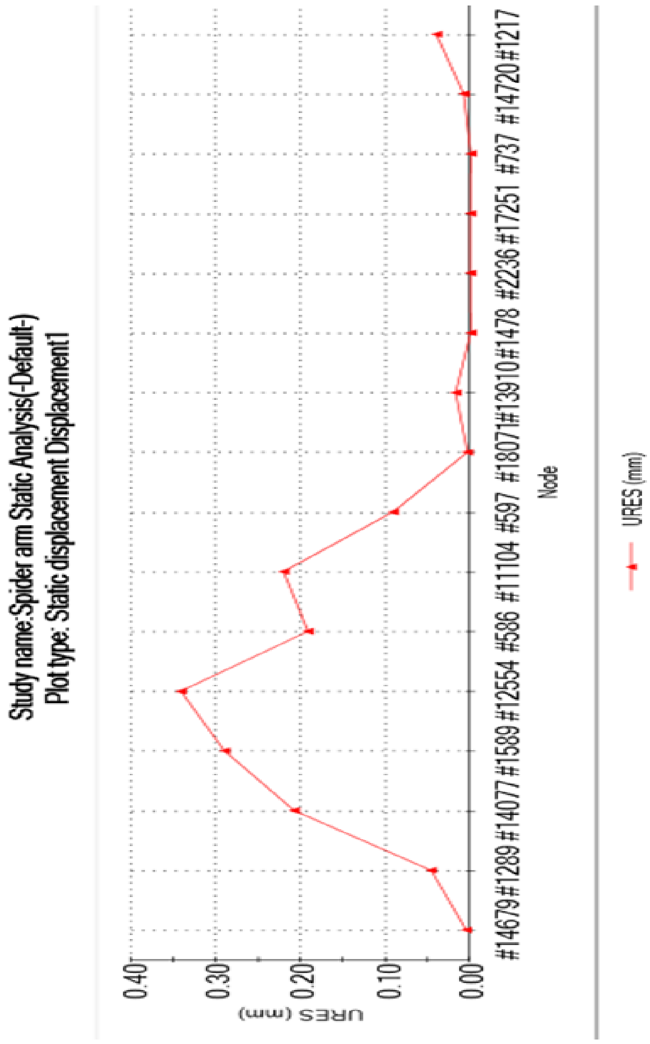


Chart -3.1.1.3: Static Displacement (Deformation)

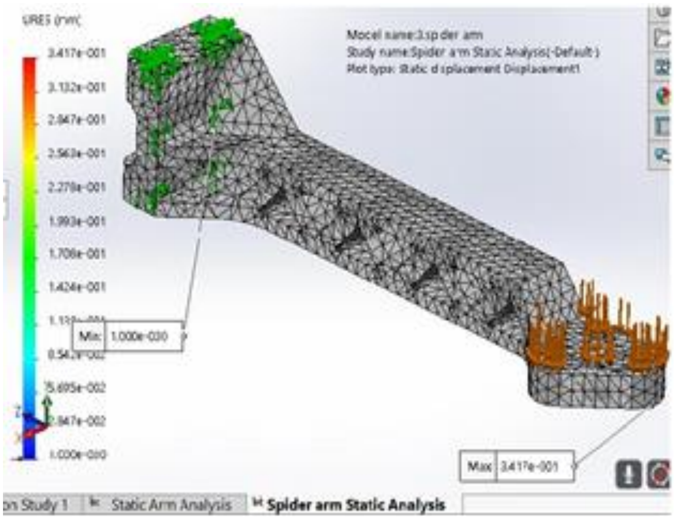


Fig - 3.1.1.c: Static Displacement (Spider Arm)

➢ **SUSPENSION BOTTOM** (STATIC ANALYSIS)

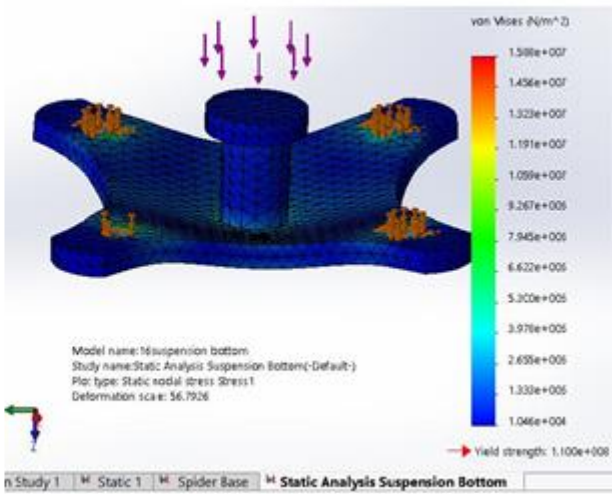


Fig3.1.2.a: Von Mises Stress Analysis (Suspension Bottom)

(Max. value =15.88 MPa)

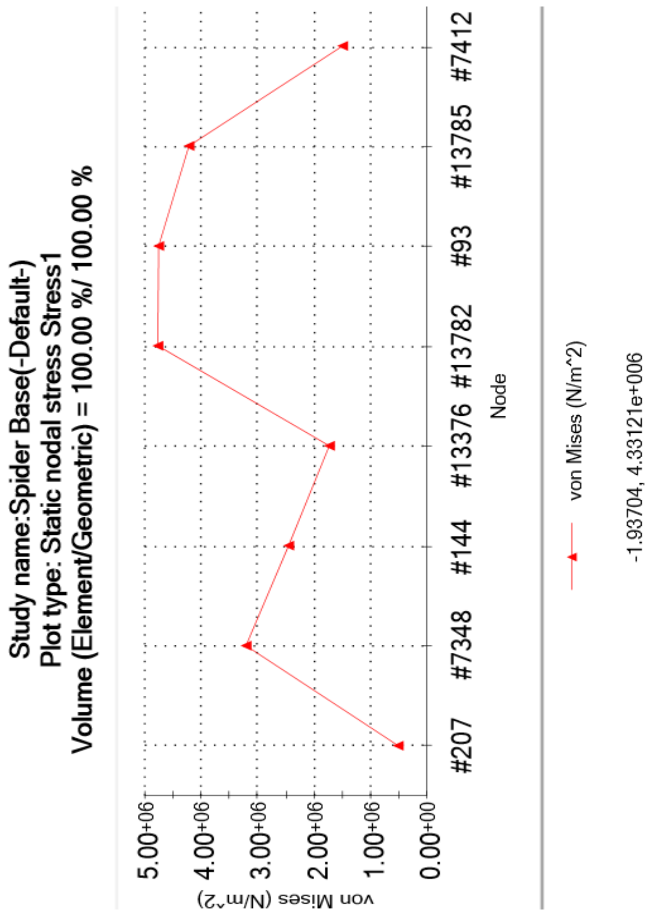


Chart -3.1.2.1: Von Mises Stress (Suspension Bottom)

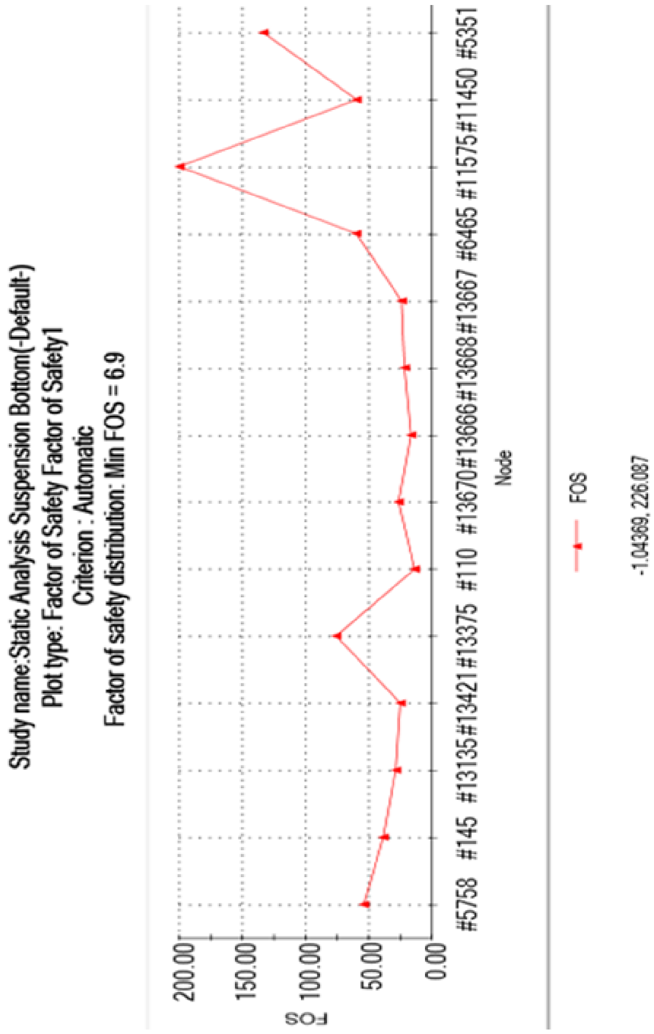


Chart -3.1.2.2: Factor of Safety (Suspension Bottom)

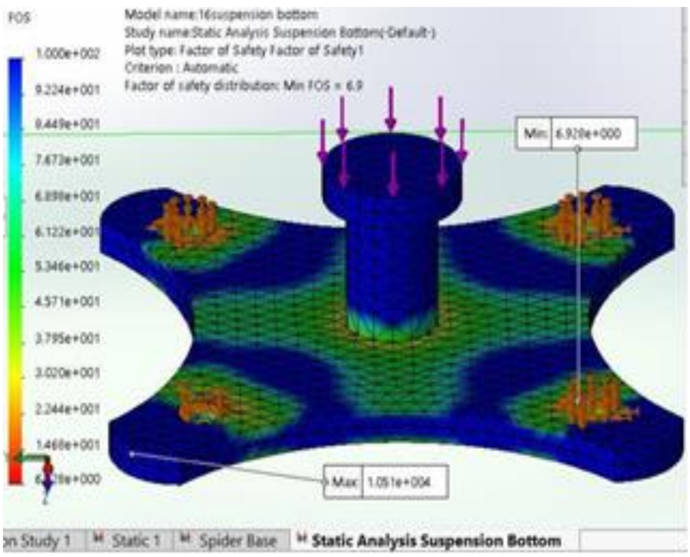


Fig - 3.1.2.b: Factor of Safety (Suspension Bottom)

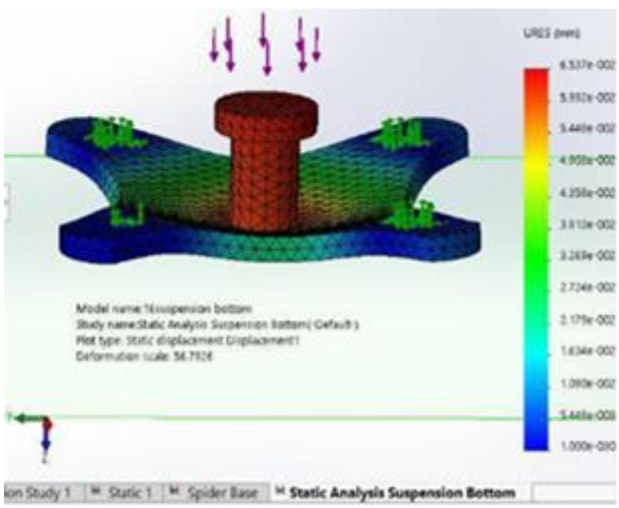


Fig - 3.1.2.c: Static Displacement (Suspension Bottom)

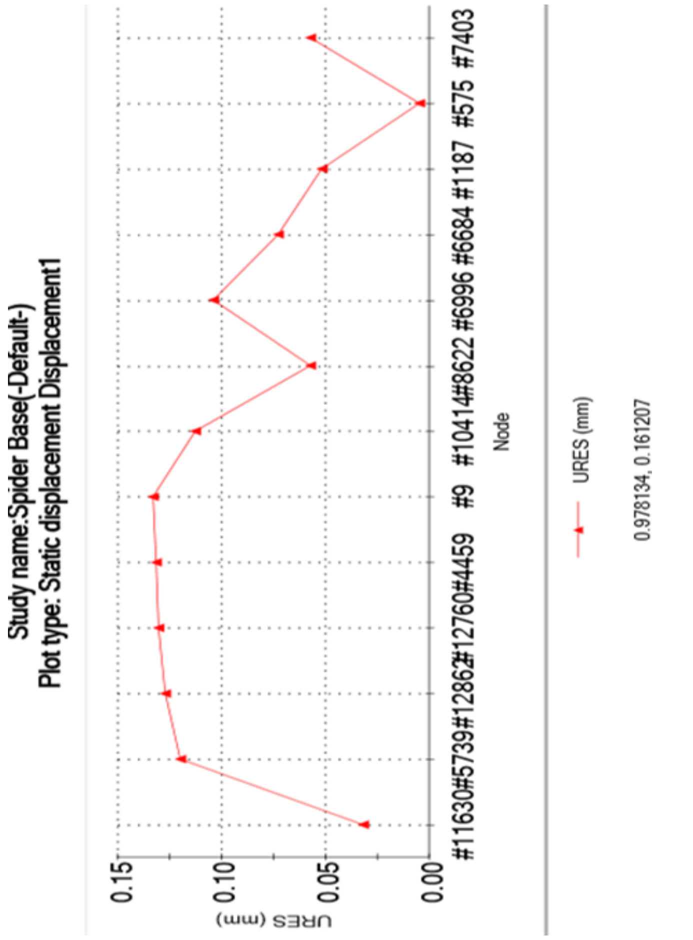


Chart -3.1.2.3: Static Displacement (Suspension Bottom)

4. ANALYSIS & RESULT

4.1 QUADCOPTER SPECIFICATIONS:

a. FRAME WEIGHT = 390gm

Frame material The Q450 V3 is a well thought out 450mm quad frame built from quality materials. The main frame is Glass fiber while the arms are constructed from ultra-durable polyamide nylon. This version 3 of the Q450 features integrated PCB connections for direct soldering of your ESCs. This eliminates the need for a power distribution board or messy multi-connectors keeping your electronics layout very tidy. V3 also comes with stronger molded arms over V1 and V2, so no more arm breakage at the motor mount on a hard landing. Assembly is a breeze with pre-threaded brass sleeves for all of the frame bolts, so no lock-nuts are required. It utilizes one size of bolt for the entire build, making the hardware very easy to keep in order and only requiring one size of hex wrench to assemble. A great feature of this frame is the large mounting tabs at the front and rear of the main frame bottom plate for mounting cameras or other accessories. This makes for a great way to take aerial video or fly FPV without the need to add any additional mounting brackets.

SPECIFICATIONS:

Width: 450mm, height: 55mm, weight: 270g (w/out electronics), motor mount bolt holes: 16/19mm.

b. (ECM + BLADES + MOTOR + NUT + SAFETY PROPELLER) X 4 =490gm

b.1 PROPELLER
Length: 10 inch (25.4cm),
Slope: 4.5 inch (11.43cm),
Material: carbon nylon,
Thickness of center: 9.7mm,
Material: carbon nylon Size: 1 x 4.5".

b.2 MOTOR
Stator diameter (mm) - 22 Stator length (mm),
Diameter of Shaft: 6 mm,
4Pc 1000 KV Brushless DC,
MAX R.P.M =8000 single,
Motor Thrust = 300 single.

b.3 BATTERY
Weight =50gm,
Rated voltage: 11.1 V,
Rated Current: 2200 m Ah 30 c/25 c,
Exact weight: 190 grams,
Plug style: xt60 plug, l X h X w: 100*20*30.

b.4 CAMERA
Weight = 100gm.

c. Arduino Uno Micro controller & Gyroscope =100gm
TOTAL WEIGHT of UAV, W
=(100+100+490+50+390+100+100) =1.330 Kg OR
~1.5 Kg

4.2 CALCULATIONS:

The Force on the four Spider Arms are Equal & calculated to be = Total Weight / 4 = (1.5* 9.81 / 4),
Therefore the Force applied for static simulation of the Spider arms = 3.67 N.
Similarly,
For the Static Analysis of Suspension Bottom
The Force that is Subjected on the Suspension Bottom would be the total Weight of the UAV = 1.5 * 9.81 N
= 14.71 N.

The Forces are assumed to be Point Loads for both Spider Arm and Suspension Bottom to minimize the complexity and processing time of the Static Simulation for the given set of Constraints (The Support is taken to be fixed during the Simulation).

The condition for lifting i.e. fly of Quadcopter is that the ratio of total thrust of the body to the total weight of the body should be minimum 1.5.

4.3 ANALYSIS RESULTS:

Table -1: Static Simulation Result

Name of the Part	Von Mises Stress (in MPa)	Deformation (in mm)	Factor of Safety
Spider Arm	4.406	0.341	6.3
Suspension Bottom	15.88	0.0653	6.9

5. CONCLUSIONS

Quadcopter will soon take Importance and will be Widely Used in Future. They will be seen taking up important roles for a variety of jobs including business in the immediate future. They could become a part of our daily lives. And it is easy to operate by a common man. Widely Used due to its Cost effectiveness and Compact size.

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