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Analysis of Quadcopter

K. Anilkumar[1], K. Sumanth[2], B. Kishore[3], T. Kondalarao[4], N. Jagadeesh[5]
Assistant Professor[1], UG Student[2, 3, 4, 5]
Department of Mechanical Engineering
RSREC, kadanuthala, India

Abstract:
The aim of this project is project to fabricate and analysis of quadcopter. Which are can be implemented in different applications like surveillance, military warfare, agriculture, searching operations and finding best rout in case of natural disasters. These Quadcopters can be used for delivering objects also. Now a day's military using these drones for target and decoy purpose. We can control this quadcopter by using transmitter and receiver. These UAVs are making some of the functions which are difficult like weather monitoring at high altitudes, radiation measurement, and pipeline inspection as simple just by sitting in front of a screen. In this is discussed on how Quadcopters are flying and making her moves. And some live test results like flight time, load bearing capacity and comparison of values which are obtained by practical testing and theoretical values which are obtained by using some standard equations.

Keywords: quadcopter, UAV, Rotors.

1. INTRODUCTION:

Quadcopters are one type of UAV which can be takeoff and land vertically which utilizes small launching pad. This quadcopter consist of four rotors which can be placed in different shapes like plus (+), cross(X) and "H" in shape. In this the cross(X) shape frame is used because of its high payload compare to remaining shapes of same size the first functional quadcopter is designed and fabricated by French scientist Étienne Oehmichen in 1924 And named as Oehmichen2. Which makes up to 1000 successful flights and flown a recording distances of 360 meters at that time. This Quadcopters consist of 2 sets of identical propellers in which one is clockwise and another one is counter clock wise. By adjusting speeds of this propellers we can change the altitude and direction of moving. And to make a stable flight we r using accelerometer and gyroscopic sensors.

2. BACKGROUND:

1] Laptop: - the laptop is used to dump the program. In to the flight controlling board y using firm ware and USB asp drivers.

2] Flight control board: - this flight control board consists of processors and it takes input signals from receiver which is sent by operator by using transmitter.

3] Electronic speed controllers: - these are called as ESC. It takes signals from flight control board and controls the speed of dc motors by varying output voltage.

5] Propellers: - These are attached to the rotating armature of the dc motor and gives thrust to the quadcopter when rotates.

6] Power Supply: - Power supply is given by means of a three cell 11.1v LiPo battery which is charged by stable B3 LiPo battery charger.

3. FORCES ACTING ON QUADCOPTER:-

The main forces which are acting on quadcopter are

3.1: Thrust: - which is acting in the direction of motion. This force must be greater than drag force. Due to this force the quadcopter gets motion.

3.2: Drag: - this force opposes the motion of the quadcopter which is acting opposite to the thrust force. This occurs due to resistive force of air to move. In Quadcopters this drag force is must small when compare to thrust force in order to move.

3.3 lift: - this force is acting vertically upward and directly proportional to speed of the dc motor, pitch and diameter of the propeller.

3.4 weight force: - this force is acting due to gravitational pull of the earth. The lift must be 2 to 3 times greater than the weight to get stable flight condition.

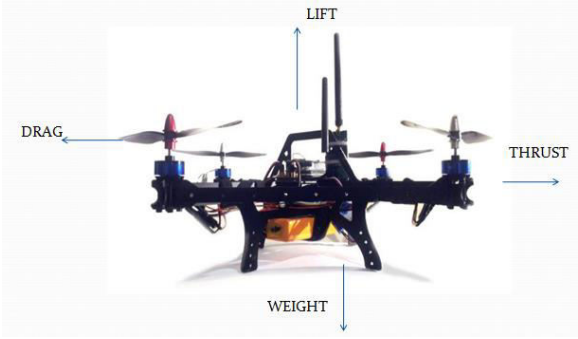

Figure.1. Forces acting on quadcopter

4. PRINCIPLE AXIS OF FLIGHT QUADCOPTER:

4.1) Yaw: It is the rotation of quadcopter about its own axis which happens when the resultant force of any one moment

(clock wise or anti clock wise) gets high value compare to other. This momentum force is concentrated at central vertical axis of the quadcopter and stats to spin itself along vertical axis.

4.2) Pitch: It is the action of the quadcopter on the basis of horizontal axis which is passed from back to the front. This happens when the vector sum of the all the forces is not zero either positive or negative due to this the quadcopter gets moves front or back.

4.3) Roll: It is the rotation of the quadcopter on the basis of horizontal axis which is passing from left extension of quadcopter to the right extension of the quadcopter. This occurs when the all motors vector sum is not zero either positive or negative. Due to this the quadcopter can move left or right.

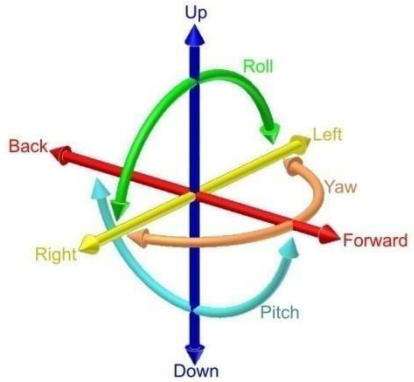

Figure.2. Axis of quadcopter

5. MOTION OF THE QUADCOPTER:

The motion of quadcopter is gets from un balanced forces. When the all forces are equal this state is called equilibrium state in this quadcopter is in stable condition in space. If any force changes its magnitude there is no equilibrium condition and the resultant force vector gain a direction and moves the quadcopter in that direction.

5.1) Take off /Landing: - take off occurs when the entire rotors along with propellers are revolving with same speed. The quad copter is going to fly based on following three principles.

a) Bernoulli's principle.
b) Momentum lifts theory.
c) Newton's third law of motion.

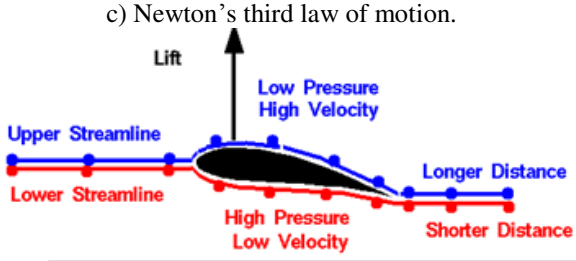

Figure. 3. Concept of lift

If the rotational speed of the rotors decrease then automatically the quadcopter lands due to gravitational pull of the earth.

5.2) Forward/Backward: The axis involved in this motion is the pitch axis. This motion occurs when the front rotors (1&4) increase their speed and back side rotors (2&3) are decreasing their speed a little bit. Due to this the vector magnitude is going to be un-balanced from this the quad copter can move forward/backward.

5.3) Right/Left motion: the axis involved in this is roll axis. The quadcopter gets this type of motion when the left or right side set of rotors are speed up and remaining set is going to be slowdown a little bit. Due this the vector magnitude gets unbalanced forces hence the quadcopter moves either left side or right side.

5.4) 360^0 Rotation: - the axis involved in this is yaw axis. This happens when the clock wise rotors gets more thrust and counter clock wise rotors gets slows down. Due to this the vector magnitude and direction rotates the quadcopter along yaw axis either in clockwise or in counter clock wise.

5. PARTS USED:-

Table .1. Specification and weight of parts used

Name of the part	Specification	Weight
Frame	F450	270g
FCB	KK 2.1.5	21g
ESC	30A	120g
Motors	1000KV, A2212	52.7 g / each
Propellers	10 X 4.5	20g
Battery	3S (11.1V)	500g
Rx and Tx set	FlySky-CT6B	10g on board

FCB – Flight Control Board
ESC – Electronic Speed Controller

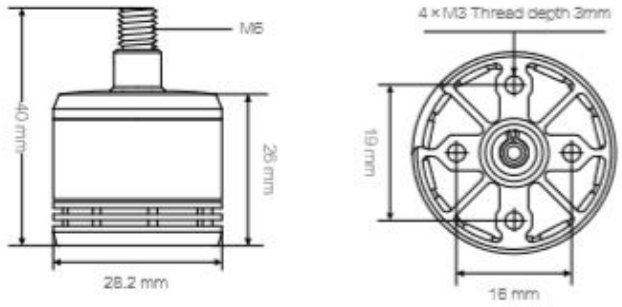

Figure.4. design of motor

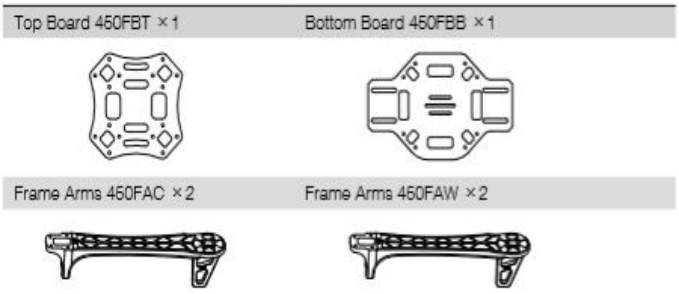

Figure.5. Frame parts

6. ANALYSIS OF QUADCOPTER:

6.1 THRUST AND VOLTAGE

Brushless dc motors are often found in different variations among all of them. We have to choose them according to requirements.

6.2 Mathematical analysis of thrust the thrust generated by the propellers can be calculated by using the following formulae

$T= (\pi D2 \rho P 2)/2$ kg

(1) T= Thrust of the propeller in grams

(2) D= Diameter of the propeller in meters ρ= Density of air (1.225 kg/m3)

(3) P= Power Multiplier, Power Multiplier can be calculated as: P= prop constant * (rpm/100) power factor Prop constant= provided in the data sheet of product Power Factor= provided in data sheet of product

7. SENSOR USED IN QUADCOPTER:

The mandatory sensors which required getting stable flight conditions are accelerometer and gyro sensors.

1) Accelerometer:

This sensor gives acceleration to the quadcopter any direction. It makes sure to complete all directions which are given by transmitter.

2) Gyroscope:

This sensor measures angular displacement and send signals to controller in order to get stable flight conditions.

8. QUADCOPTER DYNAMICS:

In Quadcopters a total of four motors are going to control the quadcopter (6 DOF) by varying the speed of the propellers by using flight controllers and esc. In the propellers one set is clockwise (CW) and other set is counter clock wise (CCW). The magnitude of forces coming from the rotator parts is going to be cancelled by each other so we can get a stable flight conditions. The vector momentum of all forces becomes zero hence there is no unwanted movement in quadcopter.

9. TESTING COMPONENTS:

9.1 Testing of motors:

The motor is tested by using voltage regulator and ammeter. The speed is tested by using digital speedometer.

Table.2. Test results of motor without propeller

VOLTS	AMPS	Speed rpm
7	0.6	7380
8	0.65	8460
10	0.75	10500

7.2 Thrust calculations:

In this test the propeller is connected to the motor and a 30A ESC is connected to motor, 11.1V LiPo battery and FlySky receiver. The motor is mounted to a wooden bar which is connected to electronic weighing machine and placed in a box in order to avoiding the contact of air to the weighing machine.

Table .3. Practical values of thrust at various rpm of motor

Rpm of motor	Thrust produced in grams
3561	223
6429	622
7124	770

Above 7200 rpm the propeller is started vibrating hence the experiment stopped here.

10. CONNECTIONS MADE:

The motors are mounted at four sides of the F450 frame. ESCs are connected to motors and signal wires are connected to the KK2.1.5 flight control board. The receiver is connected to flight controller. Battery is connected to frame inbuilt circuit board and ESC input wires also connected to frame.

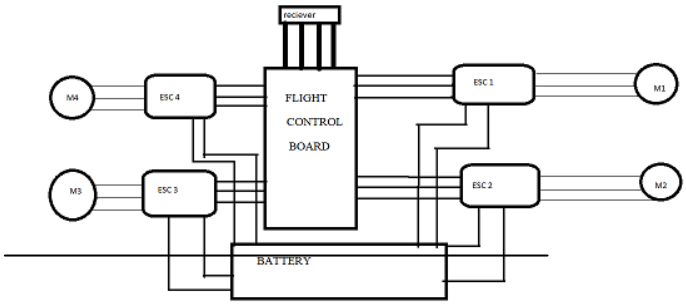

Figure. 6. Circuit connections

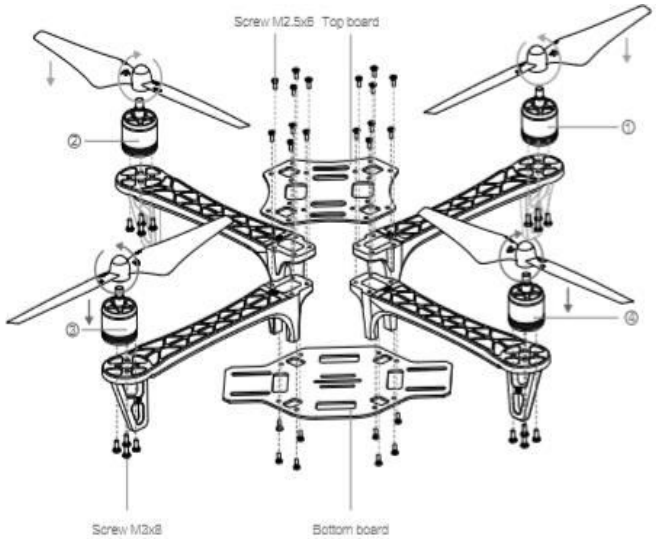

Figure.7. assembling of quadcopter

11. FLIGHT TESTS:

The quad copter is tested at outdoor under following conditions

1. Battery is fully charged before starting.
2. Always throttle is not exceeded 60%.
3. at various wind speeds.
4. at various timings to get air density changes

12. TEST RESULTS

Table .4. Obtained results

TEST	RESULTS
Weight of quadcopter	1300 grams
Load caring capacity	800 grams
Flight time	20-25 min
Range of transmitter	900 meters

13. CONCLUSION:

From this research we conducted tests on quadcopter by parts which are picked from lot of variations. We can install a camera easily to KK2.1.5 flight control board to get photos or live feed. The Quadrocopter is increasing altitude hardly when air speed is increasing. There is no considering change in flight time when tested in day and night.

14. REFERENCES

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