Design, Analysis and Fabrication of Quad copter for Medicine Delivery

[1]Akil Patheria, [2]Pranay Gadiya, [3]Avinash Gore, [4]Komal Chib

B.E. Students
Department of Mechanical Engineering,
Dr. D.Y. Patil Institute of Technology, Pune,India

Abstract—The goal of this project is to build a quad copter that can accomplish a variety of practical tasks like delivery of drugs and medicines with parallel video surveillance. The market for multipurpose drones has the potential to be expansive once proper regulations by government are passed. A quad copter can achieve stable vertical flight and can be used to monitor or collect data in a desired region. Advancement in technology have reduced the cost and increased the performance of low powered microcontrollers that allow enthusiasts to develop their own quad copter. The goal of this project is to build a quad copter to obtain stable flight, gather and store data, and to perform semi-auto commands, such as auto-homing by using wireless remote, gps tracking to deliver medical help such as blood and emergency medicines to those in need during peak traffic hours in cities. This project uses a quad copter that includes a frame, dc motors, electronic speed controllers, microcontroller, and sensor boards, batteries, rf camera, trans-receiver and gps module. Individual components will be tested and verified so that they work properly. Calibration and tuning of the pid controller will be done to obtain proper stabilization on each axis using custom pid test benches. Design will be done using various simulations software. Cost of this project will be kept minimal for commercial use in future so that it can be made available to masses.

***IndexTerms*—QuadCopter, Design, Analysis, Flight Test**

I. INTRODUCTION

A mini UAV drone is an aerial vehicle that uses four rotors for lift, steering, and stabilization. Unlike other aerial vehicles, the quad copter can achieve vertical flight in a more stable condition. The quad copter is not affected by the torque issues that a helicopter experiences due to the main rotor. A helicopter is a flying vehicle which uses rapidly spinning rotors to push air downwards, thus creating a thrust force keeping the helicopter aloft. Conventional helicopters have two rotors. These can be arranged as two coplanar rotors both providing upwards thrust, but spinning in opposite directions in order to balance the torques exerted upon the body of the helicopter. Furthermore, due to the quad copter's cyclic design, it is easier to construct and maintain. As the technology becomes more advanced and more accessible to the public, many engineers and researchers have started designing and implementing quad copters for different uses. Some quad copters in production today can hold light payloads, such as food and medical supplies, and deliver them to areas where normal planes cannot reach. The aim of this project is to build and program a quad copter that can be used todeliver medicines and drugs in emergency situations during peak traffic hours in city.This project will be a great learning opportunity for us to apply our engineeringknowledge. In order to complete the quad copter a battery, trans-receiver, GPSmodule, motors, propellers, various sensors will be selected.A UAV quad copter is an unmanned aerial vehicle with four rotating rotors used forlift and movement. It uses an electronic control system and electronic sensors to helpstabilize it. Quad copter parts have been decreasing in price over the past couple ofyears due to technological advances. As a result more hobbyists, universities, andindustries are taking advantage of this opportunity to design and develop applicationsfor the quad copter.

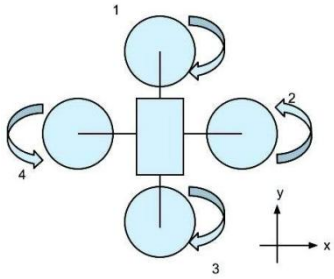

Figure 1: Quad copter Motor Rotations [1] [2]

II. LITERATURE REVIEW

QuadCopter had an incredible evolution in 21st century. Universities, students and researchers continuously work to introduce more robust controllers and modelling techniques, so that they can provide detailed and accuraterepresentations of real-life quad rotors. This section introduces some of the work presented in recent years. Aermatica Spa's Anteos is the first rotary wing RPA (remotely piloted aircraft) to have obtained official permission to fly (Permit To Fly) issued in the civil airspace, by the Italian

Civil Aviation Authority (ENAC), and will be the first able to work in non-segregated airspace. AeroQuad is an open-source hardware and software project which utilizes Arduino boards and freely provides hardware designs and software for the DIY construction of Quad copters. ArduCopter is an open-source multi copter UAV. Based on Arduino, it supports from four to eight motors, as well as traditional helicopters, and allows fully autonomous missions as well as RC control. OpenPilot is a model aircraft open-source software project. Parrot AR Drone is a small radio controlled quad copter with cameras attached to it built by Parrot SA, designed to be controllable with iOS or Android devices. Parrot AR.Drone 2.0 carries a HD 720P camera and more sensors, such as altimeter and magnetometer.

- "Design and Analysis of Quad copter" by R Nallappan, CasindraHellan Maxim and P Barath Kumar.
- "Quad copter Flight Dynamics" by Mohd Khan.
- " Design of a Quad Copter and Fabrication" by Anudeep M, G Diwakar and Ravi Katukam.

A. Statistics

The EMS system has been ignored to a large extent inIndia. If the system is not being able to save the lives of its citizens, then it amounts to the collective failure of society and a system as a whole. India is a country of paradoxes. On one hand, it has new corporate hospitals for attracting medical tourism and on the other hand, it has not been able to provide the basic primary health and necessary emergency services to the masses.

THE FOLLOWING STATISTICS SUPPORT THE ABOVE MENTIONED POINTS.

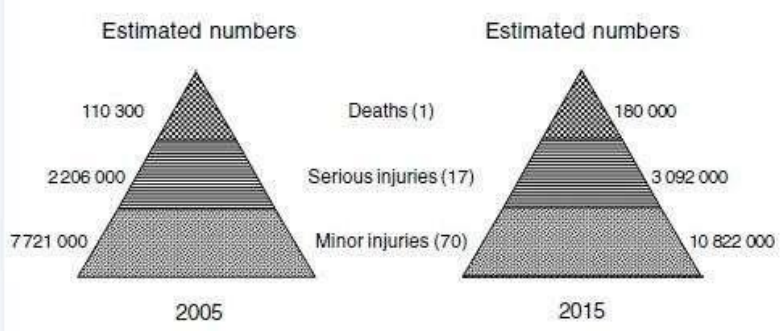

Figure 2: Estimates of death and injuries due to road trafficinjuries in India in 2005 and 2015[21][22]

B. Use of Quadcopters in Medical Emergencies –Current Scenario

• DHL PARCELCOPTER: THE NORTH SEA Its payload consists of medicines like painkillers or anticoagulants.
• MATTERNET QUADCOPTER: BHUTAN Its payload consists of antibiotics. It flies from the hospital in the Himalayan capital of Thimphu. Thetests ran in August 2014 and a rollout was plannedfor 2015.
• GOOGLE X SELF-FLYING VEHICLE: QUEENSLAND, AUSTRALIA Its payload consists of Dog treats, cattle vaccines, and a first-aid kit for farmers.[23]

III. DESIGN OF SYSTEM

A. Frame Material

Material	Density	Tensile strength	Modulus of elasticity	Cost (Rs/ kg)
Steel	7.85	551	210	200
Aluminum	2.7	310	70	600
Carbon fiber	1.8	5100	240	8000
Glass fiber	2.5	4840	100	1500

Table 1: Material Comparison [4][11][13]

After comparison of various materials available for frame body, Glass Fibre Reinforced Plastic (GFRP) is selected due to its high tensile strength, easy availability; less density hence light weight and good damping property during vibrations.

B. Frame Body

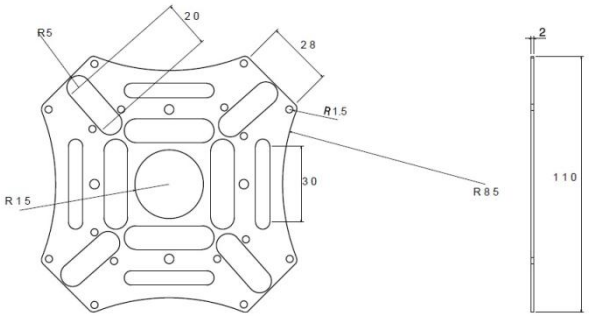

Figure 3: Upper Plate Design

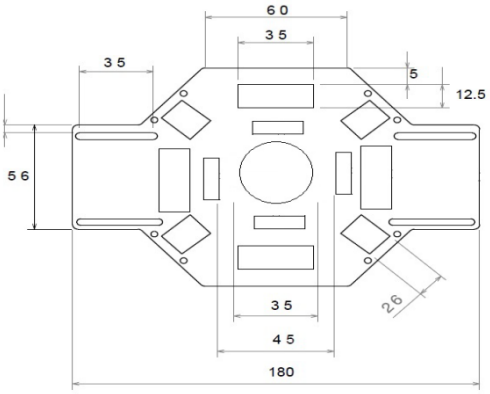

Figure 4: Lower Plate Design

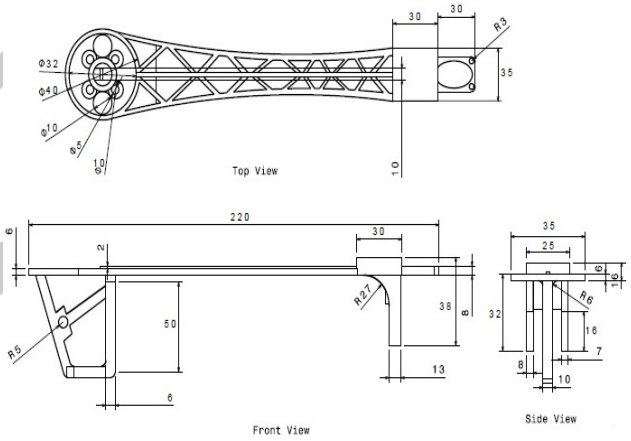

Figure 5: Arm Design

IV. ANALYSIS

After analysis of frame, stresses and deformation was obtained and it was observed that the magnitude of stress and deformation in frame are under limits hence the design of frame is rigid and sturdy and will be able to bear the stresses during operation. The frame was designed with a factor of safety of 20% and it will withhold its strength and rigidity during flight

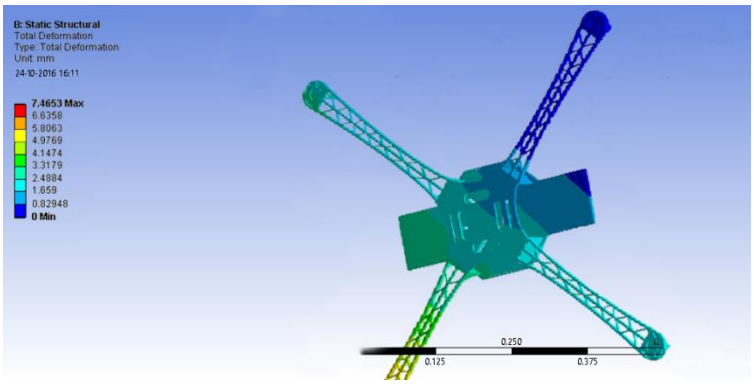

Figure 6: Total Deformation of Structure

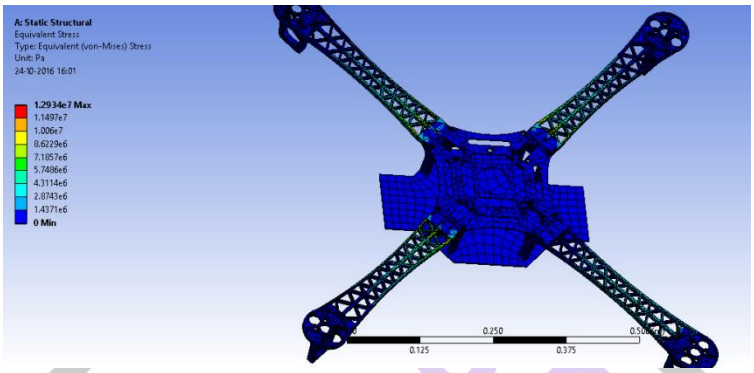

Figure 7: Von-Mises Stress

V. ELECTRONIC COMPONENTS

BLDC Motor

Total weight: 3000 gram; F.O.S. = 20 %
Approximated Weight = 3600
Weight per Motor = 3600/4 = 900 grams
Relative Velocity = 40 kmph = 11 m/s
Total Power = (98*4) + 50 = 442 Watt
Min. rpm = Min. I/P Volt * KV rating of motor * Efficiency
N= 1100 * 11.1 * 0.8 = 9800 rpm T = 442÷1046
Torque requirement for motor is 0.95 N-m [5][6]

Electronic Speed Controller

30 A Current and 3S LiPO Cell [9][12]

Propeller Blades

1000kv motor at 11.1V = 11100 rpm
10”x 4.5 Propeller size [7][8]

Power Supply

Capacity: 2200mAh
Configuration:3S/11.1V
Constant Discharge: 30C
Peak Discharge (10sec): 40C

Flight Control System

ArduPilot Mega 2.8 Multi Rotor Flight Controller
Hovering Accuracy (GPS): Vertical: +/-0.8m, Horizontal: +/-2.5m; Max Yaw Angular Velocity: 200°/s; Max Tilt Angle: 45°
Ascent/Descent: +/-6m/s

V. FLIGHT TEST

A. Vertical Test

Vertical flight with and without payload was tested to calculate time required for quad copter to climb desired height. This test was performed in parallel to a 10 story building in which height of each floor was considered as 4 meters. Total height of building was 40 meters. Our quad copter took 6.5 sec to reach top without payload and 8 sec with payload of 400 grams.

B. Flight Time

When selecting electronic components ideal flight time was calculated to be 15 minutes. During testing flight time was recorded w.r.t battery charge and without any load and with payload of approximately 400 grams.

Battery %	Flight Time (min)	Distance(m)	Flight Time (min)	Distance(m)
	Without Payload		With Payload	
25 %	3	1400	2.5	1200
50 %	6.5	3035	6	2850
75 %	11	5135	10	4800
100 %	14	6500	13	6200

Table 2: Test Data

C. Range

The range of radio frequency receiver as mentioned by manufacturer is 1000 meters. We tested it for 700 meters on a straight road in real conditions. It was found out that it took 1 minute and 30 seconds to travel 700 meters without load with 12 % battery discharge. Our Quad copter took 1 minute 45 seconds to travel 700m with 400 grams payload at a 15 % battery expense. Our limitation is range of receiver but if full potential were to be used it could travel 6500 meters with similar weather and speed.

Figure 8: Calibration of Radio Frequencies

VII. CONCLUSION

In this project our group has successfully studied the various concepts circling quad copter such as flight principle, different components required for stable flight etc. The project is completed by designing various body frame parts, doing stress and deformation analysis of frame. We have resolved several issues encountered in this project to date, and we hope to achieve our future goals. We have calculated various parameters based on some standard assumptions and narrowed down specifications of all the electrical, electronic and mechanical components required. Although a lot of work remains, we continue to be optimistic. We also tested various parameters of quad copter during actual flight and made necessary changes which were required for stable flight. The Quad copter is ready to be used as per design and suggest application. As a team, we can completely change what

function it performs and we are able to integrate any technology that would prove to be useful. This project will clearly demonstrate the goals of proving that small scale UAVs are useful across a broad range of applications.

Figure 7: Prototype Model

ACKNOWLEDGMENT

We would like to express our highest appreciation to our supportive guide, Dr. Manoj Duse. His supervision and support truly helped us during conducting our project. His never-ending supply of valuable advice and guidance has enlightened us. Next, we would like to thank Mechanical Department, all teaching and non-teaching staff for their support. We would also like to thank Electronics Department Staff for their guidance during project period. In addition, we would like to convey thanks to lecturers, for their assistance, who spent their time to teach us and impart knowledge regarding to the design & development. We would also like to thank our parents who are a constant source of inspiration for all of us. Last but not least, we would like to state our appreciation to our colleagues and peers for supporting us and administration department for their help in the project.

REFERENCES

[1] Michael Hoang; Final Report on Design, Implementation, and Testing of a UAV Quad copter. University of Manitoba, Canada

[2] Archana C.C, DiarraCheick, RenoyReji; Autonomous Navigation for Flying Robots; International Journal of Advanced Research in Computer Science and Software Engineering Volume 5, Issue 4, 2015 ISSN: 227

[3] Peter Corke; Robotics, Vision and Control; Springer; 1st ed. 2011 edition; ISBN10: 3642201431

[4] Materials Data Book, Cambridge University Engineering Department 2009 Edition

[5] Chang-Liang Xia; Brushless DC Motor Drives and Controls; 2010 Edition ASIN: B008A31SCS

[6] https://www.mpoweruk.com

[7] https://www.torquesystems.com

[8] Mohd Khan; Quad copter Flight Dynamics: International Journal of Scientific & Technology Research Volume 3, Issue 8, August 2014; ISSN 2277-8616

[9]https://web.mit.edu/

[10] http://www.ardupilot.co.uk

[11] William D. Callister, David G. Rethwisch ; Materials Science and Engineering: An Introduction 9th Edition

[12] Norman S. Nise; Control Systems Engineering 6th Edition

[13] Leonard Charles Hollaway, Chris Hall, Dr. Jian-Fei Chen; ICE Manual Of Construction Materials: Polymers And Polymer Fibre Composite 2010 Edition

[14] Mansi Joshi, Aswina P. Mohanan,Vilas J Kharat; Design and control of electronics based medical emergency system using a Quad copter: International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 4 Issue: 5

[15]S. G. Pawar, Komal Dongare, MayurDalvi, SuyogDoshi, KK Das ; Automated quad copter using android controlling System: international journal of engineering sciences & management, October-December, 2015

[16] Guneshwor Singh; Self-Navigating Quad copter; International Journal of Computer Science and Information Technologies, Vol. 6 (3), 2015, 2761-2765

[17] R Nallappan, CasindraHellan Maxim, P Barath Kumar; Design and Analysis of Quad copter: International Conference on Systems, Science, Control, Communication, Engineering and Technology 2016

[18] Anudeep M, G Diwakar, Ravi Katukam; Design of a Quad Copter and Fabrication: International Journal of Innovations in Engineering and Technology (IJIET) Vol. 4 Issue 1 August 2014

[19] Saw Kyaw, WaiHinKo, Dr.KyawSoeLwin; Basic Multi copter Control with Inertial Sensors: International Journal of Scientific and Research Publications, Volume 4, Issue 9, September 2014 1 ISSN 2250-3153

[20] Prof.A.V.Javir, Ketan Pawar, SantoshDhudum, NitinPatale, Sushant Patil; Design, Analysis and Fabrication of Quadcopter: Journal of The International Association of Advanced Technology and Science Vol. 16 MARCH 2015 ISSN-3347-4482

[21] http://www.indiastat.com

[22] http://www.ncbi.nlm.nih.gov/pmc/articles/

[23] http://www.wired.com/2015/02/drone-regulations/