Design Parameters of Indigenously Developed Quadcopter for Area Surveillance

[1]Junaid Imran Abbasi [2]Nauman Ahmed
College of Electrical and Mechanical Engineering,
National University of Science and Technology
Rawalpindi, Pakistan
1junaid.imran.abbasi@gmail.com
[2]nfornauman@gmail.com

Abstract- The surveillance becomes an arduous task in the events of natural disasters such as earthquakes. In these situations, 'Unmanned Aerial Vehicles (UAVs)' have proved their usefulness for surveillance activities. Among these mini UAVs, 'Quadcopter' is a unique design, which besides aerodynamic stability, also provides cost efficiency. Due to these characteristics, quadcopters find wide applications in diverse fields, such as media reporting, packages delivery etc. However, their utility is Pakistan is limited by the design features offered by the market, dominated by imported quadcopters. A custom-built quadcopter, at present, is not an option for specific applications / tasks. This research focuses on the design aspects of a quadcopter with the intention of developing it indigenously for specific requirements. The features of the components used in the quadcopter have been selected keeping in view the relationship between design and performance. The optimum combination will ensure that the best possible performance and efficiency is ensured. The design parameters presented in this paper can readily be employed to develop a quadcopter for specific applications.

I. INTRODUCTION

A helicopter ordinarily has one rotor, while multicopter is equipped with two or more rotors, and thus are named accordingly (e.g. four-rotor aircraft is called quadcopter, and a six-rotor aircraft is called hexacopter). In a conventional helicopter, lift is provided by the main rotor blade, while tail rotor blade offsets the aerodynamic torque. In contrast, all four rotors operate together in a quadcopter to produce upward thrust. Each rotor lifts only 1/4 of the total weight, and thus less powerful and less expensive motors can be employed. The quadcopter's movement is controlled by varying the relative speed and thus thrust of each rotor.

The unique design of a quadcopter offers a very stable platform, making it ideal for tasks such as surveillance and aerial photography. Owing to their ability to operate in difficult-to-reach terrains, they have the potential of saving human lives. The military use of quadcopters is also not uncommon; spy cameras in day and night operations is widely used remotely by soldiers.

However, specific applications require certain design features in the quadcopter. The local market is dominated by imported products and thus their usage is limited by available options. The indigenous design and development effort will provide an ability to produce a quadcopter for any specific application. This will eliminate dependence on imported products and moreover provide a less expensive option.

This paper entails the design parameters of a quadcopter, indigenously-developed as part of a student research project.

II. DESIGNING OF QUADCOPTER

The optimum performance of a quadcopter depends on the design features, as these will determine the weight, agility, maneuverability etc. The main components are designed as follows:-

A. Base Plate

The design of base plate is shown in Figure 1. It is made of fiber glass and is strong enough to hold the all-up weight.

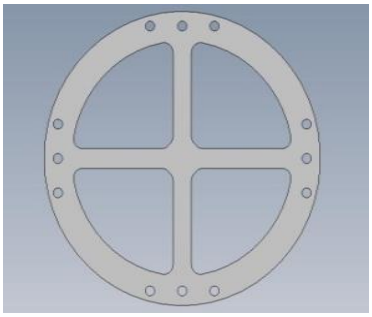

Fig. 1. Base Plate

B. Arm Rods

The arm rods should be strong enough to carry the weight of motor as well as the overall thrust provided by the motors. At the same time, these should not experience bending or provide any vibrations. Carbon fiber hollow rods are found to best suit for this purpose. Wiring is passed through hollow rods.

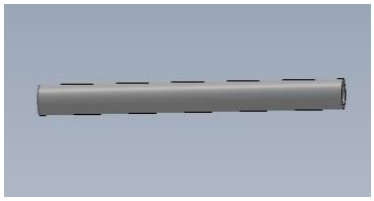

Fig. 2. Arm Rod

C. Brackets

The brackets connect arm rods to the base plate. These should be strong enough, and can be made of steel or strong polymeric material. The design used in this research project is shown in Figure 3.

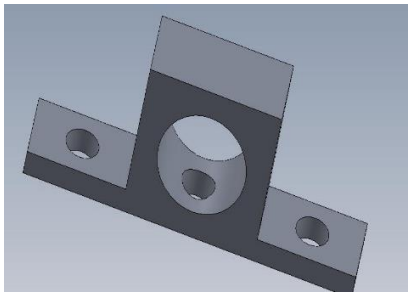

Fig. 3. Bracket

D. The Airframe and Central Platform

The airframe and central platform should be design in a flexible manner in order to adjust with varying requirements of the user, e.g. payload increase or adjustment of camera. Figure 4 shows the finalized design:-

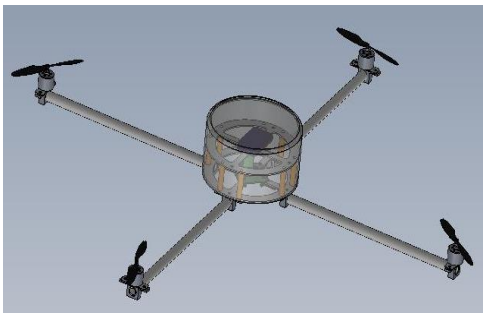

Fig. 4. Airframe and Central Platform

III. CALCULATIONS

A. Weight of quadcopter:

Assumed all-up weight = 2 kg

The detail is as under:-

a. Weight of frame & platform = 1200 g

b. Weight of camera = 400 g

c. Weight of payload = 400 g

B. Motors:

Thrust (grams) per motor = All up weight x 2 / 4

2 x 2000 / 4 = 1000 (grams) per motor

EMax BL 2215/25 is used, which has following characteristics:-

a. 950 kV

b. 930 g thrust

c. 59 g weight

d. 16.5 A current

C. Propeller:

1047 configuration is suggested with EMax BL 2215/25 motors.

D. ESC

Considering 20% safety margin, ESC with 25A capacity is used.

E. Battery

A 3-cell, 11.1 V, 5500 mAh LIPO battery is used.

F. Flight time

Flight time can be calculated as follows:

a. Battery Rating = 5500 mAh

b. Current draw for each motor for hovering = 7.8A

   For 4 motors = 31.2 A

c. 5.500 Ah/31.2 A = 0.176h

d. 0.176 * 60 = 10.5 min

IV. CONCLUSION

Designing and indigenously developing a fly-worthy and aerodynamically stable quadcopter is a time-consuming task. It requires arduous effort to achieve an acceptable level of stability. However, the increase in flight time requires research in the fields of battery technology especially. Another option is to shift to hexa or octacopter configuration to increase payload and flight time. This research will help in deciding the components and their parameters for a multicopter (quadcopter or any other configuration) for a specific need and application.

The final design of the quadcopter developed in this research project is shown in Figure 5. The product is aerodynamically very stable and gives a fight time of more than 10 minutes with manual or autonomous mode of flying.

Fig. 5. Final design of quadcopter

V. BIBLIOGRAPHY

[1] Donald Norris. *Build your own Quadcopter*. Power up Your Designs with the Parallax Elev-8. 2010

[2] Steve R. Gunn. *A small scale quadcopter platform for robotic swarm development*. A project by University of Southampton. 2013

[3] Mr. Kalpesh N. Shah1. *Design of a Quad Copter and Fabrication.* Department of Mechanical Engineering Siddhartha Institute of Technology, Vijayawada. India 2014

[4] Brian Gallenstein. *Autonomous fixed-point landing for Quadrotor*. Aerial vehicles. Polytechnic institute. 2105

[5] Irfan Anjum Manarvi. *Design and Development of a Quad Copter*. Department of Mechanical Engineering, HITEC University, Taxila Education City, Taxila, Pakistan.2014

[6] Saurabh Kumar Gaurav Kr. Naik. *Modelling and analysis of a Tricopter*. Department of Industrial Design. National Institute of Technology Rourkela. Rourkela - 769008, Orissa, India.2014

[7] Christopher Lehnert and Peter Corke. *Design and Implementation of an Open Source Micro Quadrotor*. School of Electrical Engineering and Computer Science, Queensland University of Technology. 2013

[8] K Blake Perez, David S Anderson, Kristin l Wood. *Crowd sourced design principles for leveraging the capabilities of additive Manufacturing*. Singapore University of Technology and Design.2015