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“DESIGN AND FABRICATION OF SURVEILLANCE HEXACOPTER”

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ABSTRACT

The growing human population has led to inclusion of many important activities for the convenience of humans and business opportunities. The important activities includes home deliveries of different items such as vegetables, fruits, food items, medicines etc. These deliveries are usually done via bikes or scooters which run on fossil fuels and due to increasing population and demand, fuel prices have been reaching sky heights. With increasing population, there is also a risk of national safety on borders and due to more numbers of enemy soldiers on borders, surveillance of enemy area is very difficult. To resolve these problems, we propose that, we should use compact drones for small scale delivery purposes in daily life to eliminate the pollution causing factors. The drone can also be used for surveillance. We have designed a drone to fulfill the requirements for the delivery purposes. Drone is a flying robot controlled remotely known as Unmanned Aerial Vehicle(UAV). To fly or control the drone, RC Controller is used. We have decided to base the design of our drone with 6 wings instead of 4 wings. Hence, we have named our drone as Surveillance Hexacopter.

Key Words: RC Controller, Surveillance Hexacopter, Unmanned Aerial Vehicle(UAV).

I. INTRODUCTION

Hexacopter is a type of drone with 6 motors and propellers mounted below and above on the six wings of the hexacopter. The rotation of motors is altering, as to cancel out the torque generated by the propellers. It can be also defined as a flying object which can be used for different purposes like delivery purposes and surveillance purposes in military. Our drone falls in the category of multi-rotor drone because it has multiple rotors and propellers for the flight. We have designed our drone on the basis of Hexa-X. Like Hexa-X, our drone has 6 rotors and propellers. The direction of rotation of rotors is altering to cancel out the torque generated by the propellers to make the drone more stable. Since, it is based on Hexa-X and is designed for surveillance purposes, hence we have named it as "Surveillance Hexacopter".

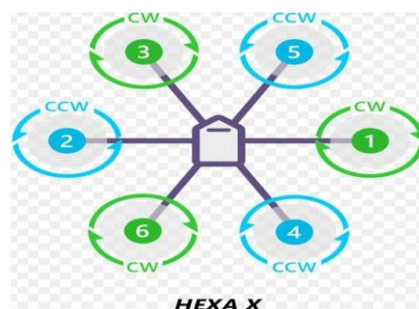


Fig.1. Block Diagram

II. LITERATURE REVIEW

A lot of research has been done for the fabrication of the drone and for that research; some conclusions are drawn by the study of various research papers. The research papers along with the learning from them are listed below:

M Urdea has work on Stress and vibration analysis of a drone frame which can help us a lot. We were able to understand about how can the stress and vibration analysis of a drone can be done through various analysis softwares.[1]

P.V. Sawalakhe et. al. have work on Simulation and Analysis of a Quadrotor UAV while Landing with the help of this research paper we were able to understand about what is Simulation and Analysis of a body or a drone and how it is done through various simulation and analysis softwares. [2]

Alipta A. Pawar et. al. have work on Surveillance Drone With the help of this research paper, we learnt about surveillance. We also learnt about different approaches to make a drone and what should be the components used in the drone according to the use of drone.[3]

G.Ding, et. al. have work on An Amateur Drone Surveillance System Based on Internet of Things with the help of this research paper we were able to understand about how to make a drone with the help of Internet of Things (IoT). With the help of IoT we can control the drone with various devices wirelessly from various locations irrespective to the location of drone.[4]

III. METHODOLOGY

Methodology is a contextual framework for research, a coherent and logical scheme based on views, beliefs, and values that guides the choices researchers make. We have also followed a methodology for our project and the steps we have followed in methodology In the first step, we identified the problem which will explain, why we chose our idea and how our drone will eliminate the problem.

After our problem was identified, we conceptualized the idea which can eliminate the problem we identified. Hence, in this step, we decided to make a drone to eliminate the problems we identified. Then we studied various research papers and got to learn about the fabrication of drone in this step. Then, we incorporated our learning from the research papers in this project. In the earlier step, we gathered most of the information for the fabrication of drone. In this step of research, we did some research for the remaining aspects of drone such as material selection for drone, selection of various components for the drone and understanding their working.

In this step, we designed the drone on CAD softwares. We fabricated the frame of drone in this step based on the design made in CAD softwares. We also installed the components on the frame to make a prototype. After the prototype was ready, we tested the various aspect of the drone such as the drone's coding, working and rectified the bugs we found in coding. We also did the structural analysis of the frame of drone. After the testing is done, we will eliminate all the issues in drone and give a demonstration of the drone. So our objective is to

- a) To design and fabricate a drone which can be used for surveillance.
- b) To design and fabricate a drone which can be used for home deliveries.
- c) To make a drone that is stable with good built quality.
- d) To make a drone at a reasonable cost.
- e) To design the 3-D model of drone.

IV. DESIGN OF HEXACOPTER FRAME

The design of our hexacopter frame is inspired from Hexa-X which is explained earlier. the frame of six wings is designed around a equilateral and equiangular hexagon which has each side of 1.5 cm and angle of hexagon is 120 degrees. This is also a reason why we named the drone as hexacopter. A hole is made on the end of each wing, so that motors can be installed on the wings. The propellers will be installed on the motors. The frame of hexacopter is made

of ABS plastic material. We have made the frame of ABS. It is a lightweight material with outstanding strength and stiffness. It is easy to fabricate. It also bonds well with adhesives, so components of drone are easy to install on the frame. It has superior weathering properties, which will allow the drone to fly in slightly bad weather conditions, provided the electrical components of drone are not affected by water.

Table No. 1: Dimensions of Hexacopter Frame

S.No.	Parameter	Dimension(in cm)
1	End-to-end length between two wings	13.1
2	Length of wing measured from centre	6.55
3	Diameter of circular hole where motor will be installed	1.5

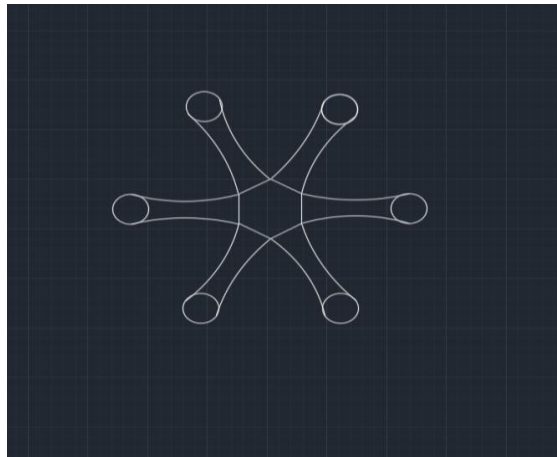


Fig.2. Autocad Design Of Hexacopter Frame

V. CALCULATION

Standard Straight Lift Up Calculation

$$\text{Angular Velocity, } \omega = \frac{2\pi N}{60}$$

$$\text{RPM of motor, } N = 50,000$$

$$\text{Angular Velocity, } \omega = \frac{2 * \pi * 50,000}{60} = 5235.98 \text{ rad/sec}$$

Calculations when turning left: in this case, the RPM of left will be decreased, say $N = 40,000$ RPM

$\text{Angular Velocity, } \omega = \frac{2 * \pi * 40,000}{60} = 4188.79 \text{ rad/sec}$ We will get the same value in the case of right turn. The difference will only be that in this case, we will decrease the RPM of motor on the right.

Dynamic Calculations: Now, Torque, $\tau = F * \text{Distance} = F * 2\pi r$ ($r = 17.5 \text{ mm}$)

$$\text{Power, } P = \frac{\text{Work done}}{\text{Time}} = \frac{2\pi r * F}{\text{Time}} = \frac{F * 2\pi r}{60/N}$$

$$\text{Power, } P = F * r * \frac{2\pi N}{60}$$

$$\text{Power, } P = \tau * \omega \text{ Watts}$$

VI. 3-D MODEL OF SURVEILLANCE HEXACOPTER

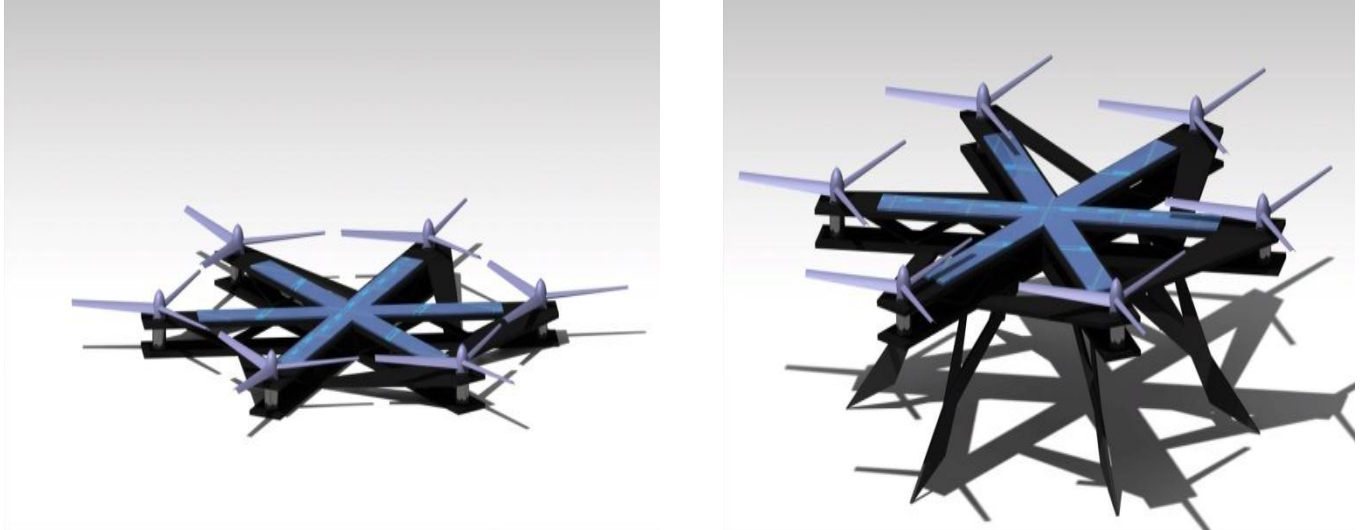


Fig.3. 3-D Model Of Surveillance Hexacopter Designed In Catia

Programming is used to feed instructions which will allow the hexacopter drone to accept commands given by RC Controller. The programming is fed in NodeMCU. The function of NodeMCU is to process commands to different components connected to NodeMCU. It is like brain of the surveillance hexacopter. It is a low-cost open source Internet of Things(IoT) platform. There are many different models of NodeMCU and we used is ESP8266 model. It is a programmable Wi-Fi module which is programmed in Arduino IDE application. The programming language used in NodeMCU is C++. The C++ language feeds instructions to control speed, flight altitude and flight paths of the surveillance hexacopter. The NodeMCU can only be programmed with C or C++. There are certain reasons why we chose C++ over C languages which are as follows:

- C++ is more fast and powerful than C language.
- Only C++ can call API online and gets digital values by RC controller without variations.

VII. CODES USED IN SURVEILLANCE

Since, the codes are 34 pages long because of which our research paper will exceed the maximum limit, so we have uploaded the codes on Google docs and made the word "Hexacopter Codes" as hyperlink. [Hexacopter Codes](#). If the hyperlink doesn't work, copy the link given below:

https://docs.google.com/document/d/1pYJ71MGEPsicEojitCzM_aB9FKf99erj/edit?usp=drivesdk&oid=115700401225885963381&rtopf=true&sd=true

VIII. UNIQUE FEATURE OF SURVEILLANCE HEXACOPTER

The most unique feature of our hexacopter drone is that, it can be controlled from anywhere as long as both drone and RC controller(which is mobile for our drone) have internet connectivity. The Node OMCU also contains Wi-Fi module.

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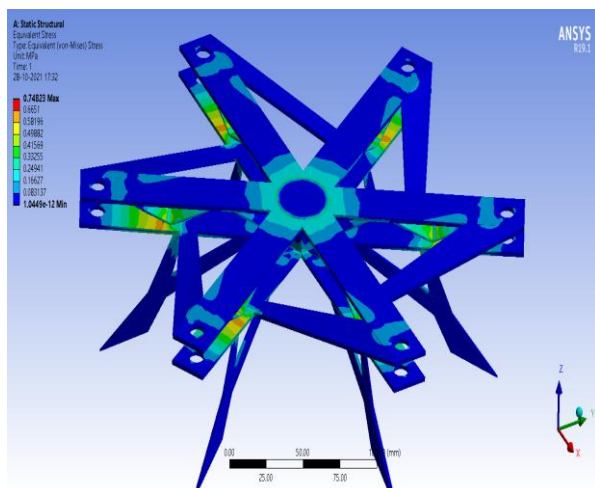


Fig.4. Total deformation of Frame

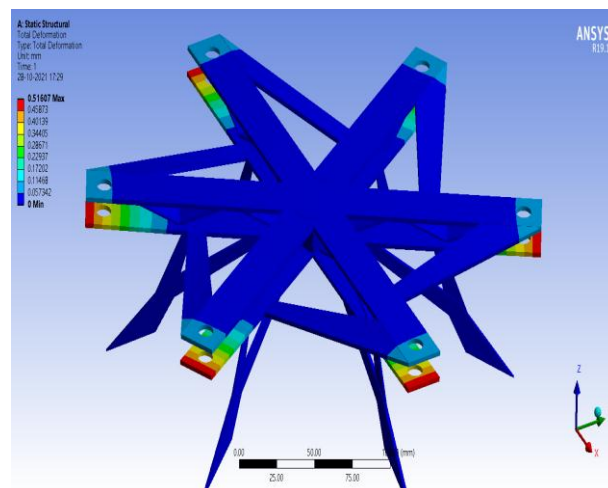


Fig.5. Stress analysis of Frame

At this point, the prototype of Surveillance Hexacopter is ready and we have done the structural analysis of frame on Ansys software. The analysis is done by setting the material to ABS plastic in the software. The results of the analysis are shown below in the table:

Table No. 2: Results of Structural Analysis in Ansys

Result of structural analysis when load of 1.76 N is applied		
S.No.	Parameter	Result
1	Directional Deformation in X-direction	Minimum: -1.6803e-002mm Maximum: 1.6883e-002mm Average: -2.1972e-006mm
2	Directional Deformation in Y-direction	Minimum: -1.5588e-002 mm Maximum: 1.5851e-002 mm Average: 3.9233e-006 mm
3	Directional Deformation in Z-direction	Minimum: -2.1903e-004 mm Maximum: 0.5169 mm Average: 5.6131e-002 mm

4	Total Deformation	Minimum: 0 Maximum: 0.51607 mm Average: 5.6693e-002 mm
5	Density	1.04e-006 <i>kg mm³</i>
6	Thermal Conductivity	2.5e-004 <i>W mm⁻¹ C⁻¹</i>
7	Zero-Thermal-Strain Reference Temperature	22 °C
8	Specific Heat	1.72e+006 <i>mJ kg⁻¹ C⁻¹</i>
9	Tensile Yield Stress	41.4 MPa
10	Tensile Ultimate Strength	44.3 MPa
11	Equivalent Stress	Minimum: 1.0449e-012 MPa Maximum: 0.74823 MPa Average: 8.714e-002 MPa
12	Moment Load	0.79 N-mm
13	Safety Factor	15

IX. RESULT & CONCLUSION

We have developed a budget drone named as "Surveillance Hexacopter" and have conducted structural analysis of structure of surveillance hexacopter's frame. The complete parameters and results of the analysis are already explained in "STRUCTURAL ANALYSIS OF SURVEILLANCE HEXACOPTER" topic. The overall cost of the drone is Rs. 5,230 and the detailed cost report is stated in table of "COST REPORT" topic. The surveillance hexacopter can be used for delivery purposes and surveillance as well for military purpose. This drone can be controlled from anywhere as long as both the surveillance hexacopter and RC controller have internet connectivity.

The hexacopter can be controlled from anywhere, when both drone and RC controller will have internet connectivity. The surveillance hexacopter prototype has been manufactured at an affordable price. If the surveillance hexacopter is mass produced, then its cost will get reduced.

X. FUTURE SCOPE

The surveillance hexacopter manufactured in this project can be utilized efficiently in different activities for human comfort like home deliveries of necessary items like vegetables, fruits, food items, medicines, groceries etc. In today's times, bikes and scooters which run on fossil fuels and leads to environmental degradation. The problem of environmental degradation can be reduced significantly in India by the use of surveillance hexacopter because it runs on electricity. The other benefit of using drone is that, the deliveries will take much lesser time than the on-road deliveries cause there is no traffic in air.

This surveillance hexacopter can also be utilized in military services. In today's era, the borders can be breached which is point of concern for country's safety. With many enemy soldiers on the enemy borders, manual inspection is very difficult. The surveillance hexacopter can be used to overcome the difficulty in manual inspection because it is small in

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size and for spying activities, it can be camouflaged which will make it invisible to enemy soldiers.

The surveillance hexacopter can be used for many activities and can be sold to customers. When more people will consider buying drones for commercial use and price will be reduced, when it can be mass manufactured.

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