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ROTORCRAFT-Design & Development Of An Unmanned Aerial Vehicle

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Abstract – *This paper contains the designing and manufacturing of UAV. Unmanned Aerial Vehicles (UAV's) are the aircrafts that fly without any human being onboard. UAV's are usually in the form of small aerial platforms that have rotating blades. We are witnessing the advent of a new era of robots "Aerial Vehicles" that can autonomously fly in natural environments. They can give great maneuverability, stability and control. These kinds of air-crafts can be used in different military missions such as surveillance, battle damage assessment, communication relay, mine sweeping, hazardous substance detection and radar jamming. Most importantly they can provide access to areas that are hard to reach and/or dangerous. UAV's can be sent to investigate areas without risking human lives.*
This project titled "ROTOR-CRAFT" is connected with the development and control of an Unmanned Aerial Vehicle. Using different components and developing the design, for betterment of the society which would be useful for multipurpose applications.

Key Words: **Aerial Vehicles, UAV, manoeuvrability, etc**

1. INTRODUCTION

This design is the next form of helicopters having more aerodynamic stability. Design is developed so as to fulfill the purpose of stability, safety and pay load capacity. This design costs less compared to other available multi-rotors available in market of same capacity. The improvement in design is mainly based on the following aspects of improvement:

1) Light Weight frame.
2) Strength due to 3D printed parts.
3) Improved thrust due to ducting.
4) Safety from propellers to humans due to outer casing of each side.
5) User Friendly. (Controlling is same as that of conventional multi rotors.)
6) Beneficial due to more carrying space for transportation.
7) As design is less complicated, easy to manufacture.
8) Less costly as compared to existing drones.

1.1 LIMITATIONS OF EXISTING UAV'S

Several limitations in the existing system are stated & detailed below:
•Less carrying space
•Limited payload
•No safety for propellers
•Specific application oriented
•Noisy
•Non sustainable to structural impacts during operation.

1) Costly*:* To deliver packages from one place to other leads to increased fuel consumption and this thereby increases air pollution and expenditure.

2) Large amount of man-power*:* Transportation of goods is not limited to a particular area so, large number of skilled manpower is required for transporting packages.

3) Topographical limitations*:* Topographical aspects may vary from place to place thus putting additional burden on human skills.

4) Human Endangerment*:* Emotions such as fear, nervousness and tension can lead to wrong decision which may result in fatal consequence.

As Human efforts lack in some complex areas to find out the easiest solution in shorter time, a fusion of cost effective and stabilized design with advanced controller is designed which leads to safe flight.

1.2 NEED

Though existing UAV's are widely used in various fields successfully, there are some areas such as carrying space, multiple application oriented attachments, stability, balancing, safety from hazards, stability, balancing, safety[4] from hazards, battery backup, VTOL (vertical take of and landing), where improvement can be done so as to increase its efficiency and performance.

2. CALCULATIONS :-

1. Weight:

As Total Weight of the UAV is up to **2600** grams, and payload is **1500** grams referring the above table, required thrust is calculated by considering the weight.

2. Thrust calculation:

Equivalent thrust required = **(1500+2600)** ×**1.2**
[Assuming thrust required to lift is **20%** greater than the total weight]

= (4100×1.2)

= **4920** grams

3. Motor and Propeller selection:

MOTOR SELECTION:

BLDC (Brush Less Direct Current) motors are used in prototypes of multi rotors.

As we need (4920÷6) **= 820** grams of thrust per motor.

So we selected **1180** kV BLDC motor.

SPECIFICATIONS:

Max. Thrust per motor (grams): **1200**
kV (rpm/v): **1180**
Max. Power (W): **180**

PROPELLER:

Propellers convert **Motor Torque** force into **Thrust Force**.

PROPELLER SELECTION:

As per the motors specification, propeller **1045** is recommended.

SPECIFICATIONS:

Designation of 1045

10 = Diameter of propeller (in inches) = 254 millimeter.
4.5 = Pitch of propeller (in inches) **=**114.3 millimeter.

4. Payload:

The total load that is to be lifted for application purposes during the flight for long time is called as pay load. Assume payload to be **1500** gram.

5. Material Selection:

Selection of material is a key aspect while designing the model. Because of the requirements that are needed to keep the structure light in weight as possible. Lighter the weight of the structure more is the payload and flight time. Also the material should remain stiff as well[2].
For fulfilling these requirements, following properties of materials are to be focused.
High Stiffness
Low Density
High Strength

6. Frame Design: As per the propeller and motor specifications, dimensions and tolerances are decided. We made our design of Rotorcraft in CATIA software.

3. IDEAS DEVELOPED

CAD Designing in CATIA V5 for overcoming the limitations**:**

Fig.[1] Rendered image of CAD model.

This was the first design where we increased the carrying capacity, carrying space over and beneath, protecting and safeguarding the propellers by using ducting and a new concept of overlapping of propellers.
A rectangular space for carrying any kind of object overhead.

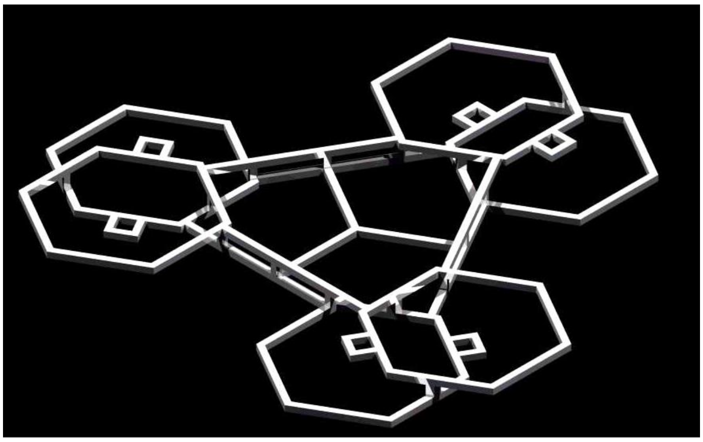
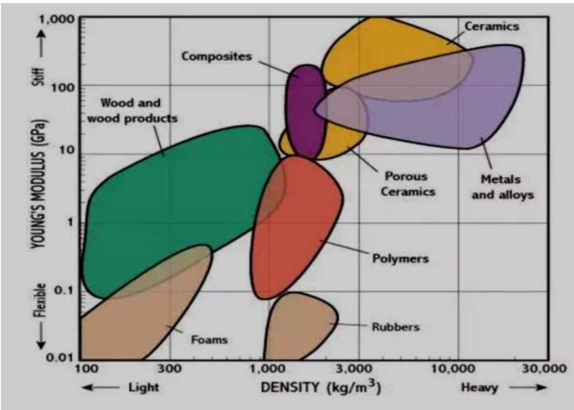


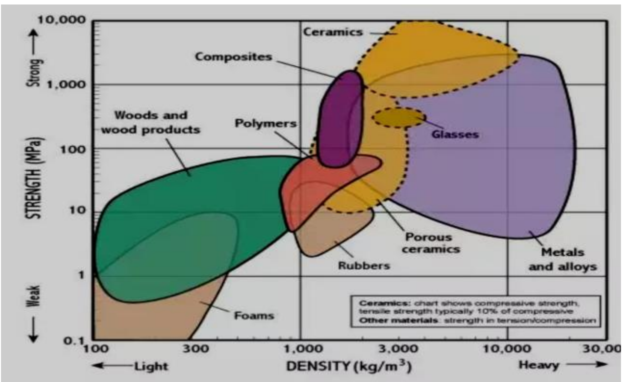
Fig.[2] Rendered Image of developed CAD model

Developing the earlier design and achieving more carrying space, more stability & light in weight. Using the geometrical concept of triangularity (tripod) being the stable design. Hexagonal rings with respect to aerodynamic stability and material limitations. Truss formation for more strength and stability.

4. MATERIAL SELECTION:

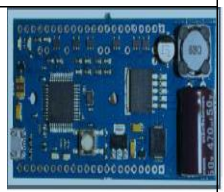


Graph [1] Density Vs. Young's Modulus



Graph [2] Density Vs. Strength

5. ELECTRONIC COMPONENTS USED

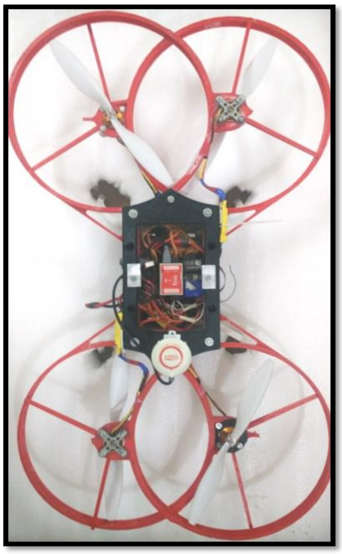
COMPONENT	FUNCTION	IMAGE
Flight controller	Synchronizes the function of all motors	
E.S.C.	Controls speed of the motors	
Battery	D.C. Power supply	
Motor and Propeller	Converts torque force into thrust force	
Power Distribution Board	Distribution of power to components	
Transmitter and receiver	Receiving and transmitting signals	
G.P.S.	Enables the feature called back to home	

6. MANUFACTURING OF DESIGNED MODEL:

IDEA NO.1

Material	Foam sheet
Manufacturing process	Water jet machining
Density	400 kg/m³
Strength	10 MPa
Young's modulus	0.8 GPa
Result	Failed
Reason	Due to vibrations

IDEA NO. 2

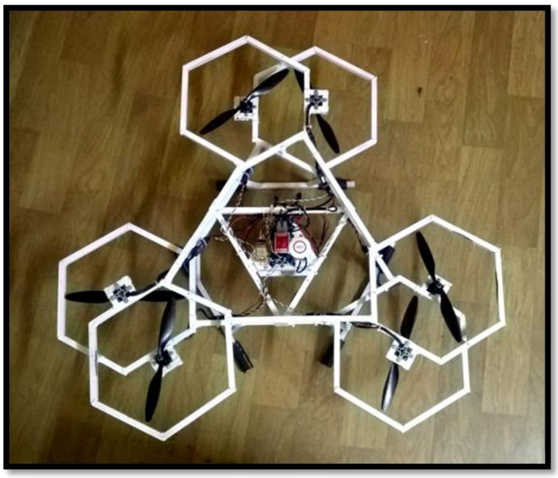


Material	Plastic (PLA) Poly-Lactic-Acid
Density	1200 kg/m³
Strength	90 MPa
Young's modulus	10 GPa
Manufacturing process	Fused Deposition Modeling (50% solid)
Result	Failed due to **less** solid percentage during manufacturing

IDEA NO. 3

Material	Plastic (PLA) Poly-Lactic-Acid
Density	1200 kg/m^3
Strength	90 MPa
Young's modulus	10 GPa
Manufacturing process	Fused Deposition Modeling (80% solid)
Result	Successful flight with enhanced stability and better structural parameters.

IDEA NO. 4



Material	Alminium
Density	2700 kg/m^3
Strength	70-700 MPa
Young's modulus	69 GPa
Manufacturing process	Spot Welding
Result	Completely stable design and better performance during testing.

7. Structural and Static Fluid Flow Analysis

We used ANSYS software for fluid flow and structural impact analysis. The results were as follows:-

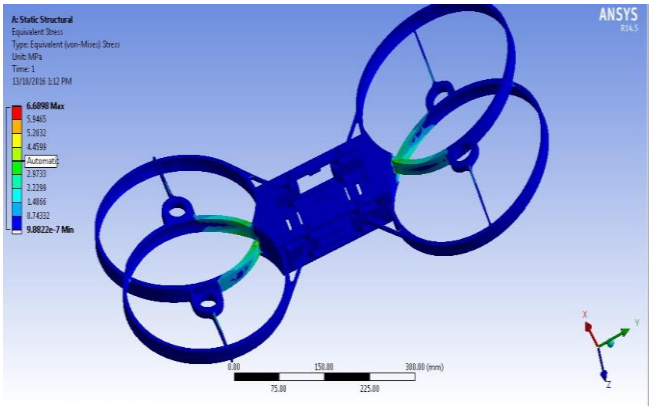


Fig [3]. Static Structural Deformation

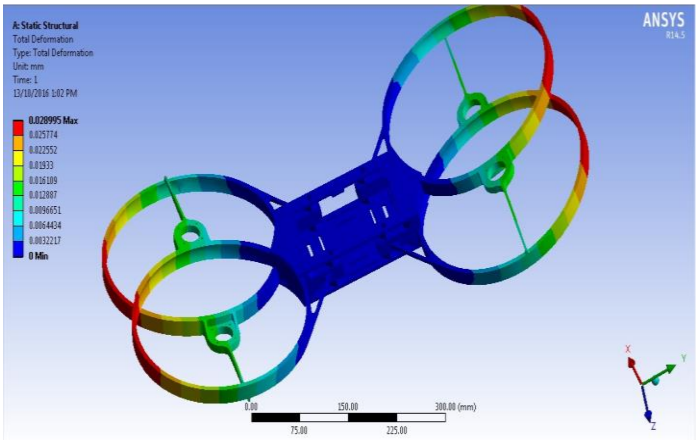


Fig.[4] Static Structural Deformation

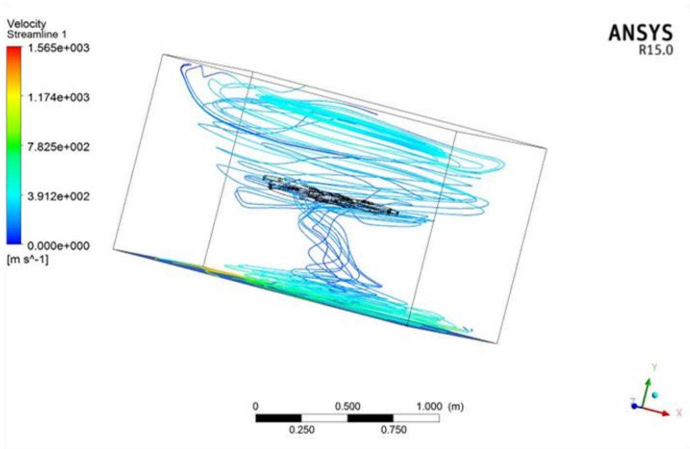


Fig.[5] Fluid flow Study on ANSYS FLUENT.

Table -1: Comparison of the ideas.

	Material and manufacturing process	Stability	Weight	Cost
1	**Material:** foam sheets **process:** water jet machining	**Less** (due to H-frame)	**Less** (due to less density of foam)	**High**
2	**Material:** polymer(50% solid) **Process:** FDM	**Less**	**More** (polymer is more heavy than foam)	**High**
3	**Material:** polymer(80% solid) **Process:** FDM	**Less**	**Very high** due to more solid percentage (not feasible)	**High**
4	**Material:** Aluminium **Process:** Aluminium welding	**More stable** due to 120◦ equidistant structure	**Less** (as hollow Aluminium bars are welded to each other)	**Low**

8. APPLICATIONS

APPLICATIONS → **FUTURESCOPE**

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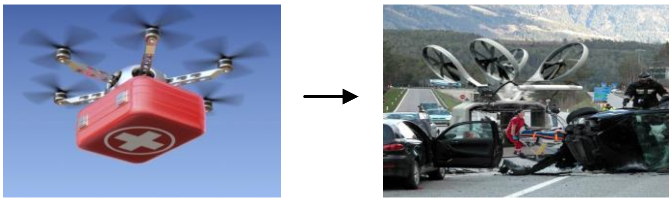
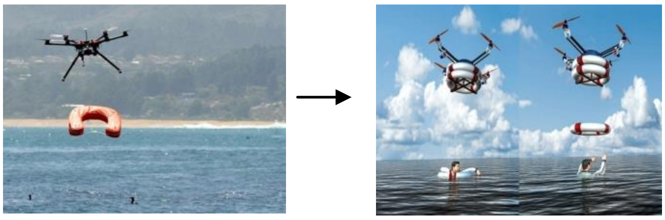
AGRICULTURE: Recently multi-rotors are used for the purpose of spraying fertilizers. Limited sprayers are used because of its limitations. Overcoming the limitations would help increasing the number of sprayers carried with extra carrying capacity.



MEDICAL: Nowadays multi-rotors are used for carrying First Aid Kits through air. Advancement could take place in form of an Air Ambulance to overcome medical emergencies



DISASTER MANAGEMENT: These days multi-rotors are used for saving people from natural disasters like floods, earthquakes etc. It can be further optimized for carrying more safeguards for saving more people at the same time.

AERIAL PHOTOGRAPHY: These days quad-copter is tremendously seen catching video & photographs at special occasions. Further it could be made as precise so as to use it for spying purposes for military needs.

HIGHWAY MONITORING: Drones are used for controlling and monitoring the traffic on highways.

TRANSPORTATION: Multi-Rotors could be used in near future for transportation of object from one place to another easily and faster.

INDUSTRIAL INSPECTION: Multi-Rotors could be useful for the industrial inspection easily which would help the supervisor to find out all round defects easily.

9. CONCLUSIONS

From above calculations and results we conclude that Idea no. 4 is selected as the most effective and stabilized design having following features:

- 1.5 Kg payload
- Light weight frame of 2690 grams
- Increased carrying space at the top
- Safeguard for propellers
- Stable design

With this design we can perform multiple applications by just changing the attachments externally.

For example: A First Aid box with emergency prescription can be used to help saving a human life during an accident on a highway with carrying attachment. Thereafter a tank full of pesticides and sprayers can be attached above and beneath it respectively and can be used for Agricultural pesticide spraying application and also can be used like the conventional ones for photography in the meanwhile.

Hence, multiple applications can be performed using this single model.

TARGETS ACHIEVED:

- More payload
- Less weight
- Carrying space
- Safeguard for propellers
- Stable design
- Less maintenance
- Multiple Application Oriented.

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