'STUDY OF DESIGNING AND TESTING OF FIRE-FIGHTING DRONE USING HOSE PIPE'- A REVIEW.

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Abstract: The design of any modified fire-protection system is an exact science that takes into account a material, thermal analysis of installed systems which became a challenge. The goal of this challenge is to develop the technologies required for drone to assist in firefighting operations. In this paper we are reviewing various research papers regarding designing and testing a fire-fighting drone. The main challenge is to design a UAV system which can carry both static and dynamic load of a water column. Following review illuminates various aspects of designing and testing that are required to make a drone which can withstand all the forces, stresses and vibrations generated while operating. Also, study of all the controlling parameters for better and smooth controlling of a drone is included. It will include design of profiled frame & its analysis, selection of standard propellers & its analysis, thrust calculation of water column, material selection. Our prime aim is to design an unmanned fire-fighting system which can cope up with fire hazards and increase safety of fire fighters to next level.

***Keyword* - UAV, design, hexacopter, fire-fighting drone, analysis, fire-fighting system.**

INTRODUCTION

One of the major reasons of death due to fire accidents in India is due to the lack of accessibility of fire-fighting systems and the never-ending traffic due to which the fire fighters are unable to reach the required destination on time and thereby reducing the efficiency of the fire-fighting systems. To overcome this problem, we are here designing a firefighting drone model which even a civilian can easily operate. Motivation behind this is to create a strong backup option to control fire in a limit before fire-fighting team gets into action and prevent further damage.

Therefore, we will design such a frame that is better than the conventional frames available and will be strong, sturdy and spacious enough that all the equipment that are proposed will be mounted ergonomically. Overall, the improved design will be an additional feature to make firefighting system more efficient and safe.

LITERATURE REVIEW

[1] R. Steijl, et. al., **"A Framework for CFD Analysis of Helicopter Rotors in Hover and Forward Flight"**, International Journal for Numerical Methods in Fluids, vol.51, January 2006, page no. 819-847, concluded that a CFD framework has been presented and validated which allows the efficient and accurate computation of helicopter rotor flows. Results have been obtained for hovering and forward-flying rotors and comparisons against experimental data are encouraging. The validation cases covered a wide range of Mach numbers and angles, and for all cases the proposed method resulted in high-quality grids and efficient CPU times. The superiority of the proposed treatment for the moving blades was demonstrated and high-quality grids were obtained both in the near- and far-field of the domain. In contrast, the TFI method resulted in highly skewed cells near the blade especially in the vicinity of the leading edge at moderate-to-high pitch angles. Blade flapping was also found to affect the grid quality near the tip. Again, the current method provided a solution with grids of high quality able to capture the blade loading.

[2] John Steven Monk, **"A Propeller Design and Analysis Capability Evaluation for High Altitude Application"**, University of Witwatersrand, Johannesburg, 2010, page no.1-166, concluded that the selection of propeller is to be determined by the comparison between the flow field of static propeller in isolation and that of the flow field induced through the wind tunnel. The radially graded momentum theory of Larabbee (1984) was able to reasonably accurately predict thrust coefficient for propeller over the required wide range of propeller pitch angles, thrust setting in UAV simulation. The design method used in this paper was capable of producing a propeller design that could provide sufficient thrust over a large range of altitudes (0-15000 m). These design and analysis capabilities cover flight conditions from take-off at sea level to the low air density, high true airspeed and high blade Mach numbers of high altitude flight.

[3] S. Subhash, et. al., **"CFD Analysis of a Propeller Flow and Cavitation"**, International Journal of Computer Applications, vol.55, issue.16, October 2012, page no. 26-33, have carried CFD analysis of a propeller flow and cavitation. As experiments are very expensive and time consuming, so they used Fluent 6.3 software to get complete computational solution for the flow. Here continuum was chosen as fluid and the properties of water were assigned to it hence when the operating pressure was lowered below the vapour pressure of surrounding liquid it stimulates the cavitation. They had solved advance phenomenon like cavitation of the propeller. They have represented the performance of the propeller in terms of non-dimensional coefficient i.e. thrust coefficient (k_T), torque coefficient (k_Q) and efficiency and their variation with advanced coefficients (J). they had also estimated thrust and torque from the computational solutions for different rotational speed of the propeller. Here two phases are considered, water and water vapour and also showed the performance of the propeller in cavitating and non-cavitating conditions. They have showed development of cavities on propeller blade and comparison between CFD and experiments which clearly shows that water got vaporised in particular area and this portion of the propeller blade is made to cavitate, thus it reduces the thrust generated by the propeller and slightly increase the torque demand. This software can solve open water characteristics of propeller with reasonable characteristics.

[4] Mohd Khan, **"Quadcopter Flight Dynamics"**, International Journal of Scientific and Technology Research, vol.3, issue.8, August 2014, page no.130-135, concluded that a voltage supply is required for thrust adjustment of the rotors and to perform standard flight operations. The ratio of total thrust depending on the angle ratio to find thrust of each rotor which is required for calculation of voltage supply for required RPM for each independent rotor. The solution lays the foundation for further use in control scheme to develop a way to autonomously control the copter for flight stability and precision manoeuvring when following a flight path. The procedure on varying the thrust direction of rotors is also illustrated to perform the standard flight operations. It also provides solution to handle the Quadcopter with angular precision by illustrating how the spin of the four rotors should be varied simultaneously to achieve correct angular orientation along with standard flight operations such as taking-off, landing and hovering at an altitude.

[5] Aditya Intwala, Yash Parikh, **"A Review on Vertical Take-off and Landing Vehicles"**, IJIRAE, vol.2, issue.2, February 2015, page no.186-191, has stated that Vertical Take Off and Landing Vehicles (VTOL) are the ones which can take off and land from the same place without need of long runway. This paper focuses on how the VTOL emerged gradually over the years. VTOL has three types wing type, ducted type and helicopter type out of which ducted type is better since it provides better lifting capacity. There are dualcopter, tricopter, quadcopter, hexacopter and octacopter configuration, from which quadcopter configuration is good because it has better lifting capacity, better stability, cost effective and much more. Also, quadcopter has two configurations i.e. + or X in shape. + is used for flying and X is used for photography. For small scale application but high lifting capacity quadcopter can be used as it is compact in design with high payload carrying capacity.

[6] Pan Wei, et. al., **"The Design of Quadcopter Frame Based on Finite Element Analysis"**, 3rd International Conference on Mechatronics, Robotics and Automation, 2015, page no.1353-1356, stated the important role of Finite Element Analysis in the Frame design. They showed the comparison between profiled frame and the X-frame and how the profiled frame is better than the X-frame. It is stated that profile frame has larger space and centre of gravity is simple and quick to position. It can support the machine arm and tripod and can have more expansion holes to facilitate post product upgrades. It takes up little space when folded and is easy to carry whereas X-frame's design is simple, good symmetry, more flexible and suitable for stunt flying, but have limited space and inconvenient for post upgrade. They have stated, that under bending and twisting load, deformation is closely related to the cross-sectional shape. Stiffness of the solid structure is smaller than the hollow structure. The torsional stiffness related to closed square section is better than closed circular cross-section. Changing the cross-sectional profile and wall thickness is used mainly to change the stiffness. They have analysed their work using FEA and proposed two responses-

(1) Reduce the rate of loading and unloading equipment and make loading-unloading to complete in a quasi-static state.

(2) The frame can be equipped with vibration isolation equipment that has better high frequency filtering performance. From this we can get detailed stress-strain contours modal analysis information diagrams and corresponding data to guide the improvement of design and decrease the cost of design.

[7] Endrowednes Kuantama, et. al., **"Quadcopter Body Frame Model and Analysis"**, Annals of University of Oradea, issue.1, May 2016, page no.71-74, stated that Quadcopter frame modelling is useful to analyse the reliability of body frame part and to help determine the type of rotor and propeller in order to assure the necessary flight acceleration. They said that quadcopter flight stability is influenced by the resulting thrust, by the distance between each rotor propeller and also by the frame rigidity; the frame has been designed to be as light as possible, meanwhile maintaining the strength to carry the load. Also, the FEA method showed that the presence of rotational velocities in each propeller flow field will significantly affect the thrust efficiency which can cause flight instability or body frame vibration. They found that prior to analysing the strength and rigidity of body frame, the type of rotor and propeller which will be used must be decided first. They selected the rotor specification stated in

this research, 560 (mm) distance between rotor and 406x127 (mm) propeller, the maximum angular velocity that can be used is 7680 (rpm) which generated 21 (N) thrust.

[8] Parag Parihar, et. al., **"Design and Development Analysis Quadcopter"**, IJACT, vol.5, issue 6, June 2016, page no.2128-2133, has stated in his research paper that the selection of propellers, frame size and calculation of thrust to weight ratio depends on certain parameters. The aforementioned parameters are dependent on the following:

(a) How to select ESC: Selection of ESC depends on the capacity of battery. The formula is 20C where C means the max safe charging rate.

(b) How to select frame size: For selection of frame size the propeller size should be calculated first. The formula is n x m where

n= diameter of propellers in inches

m= pitch of propeller in inch

(c) How to calculate thrust to weight ratio: For calculation of thrust to weight ratio, we use the formula=total thrust/total weight. For the drone to fly the minimum ratio should be 1.5

[9] M. Hassanalian and A. Abdelkefi, **"Classification, Application and Design Challenge of Drones: A Review"**, Progress in Aerospace Science, April 2017, page no.1-33, have given a new classification of these drones was first proposed. This classification includes various classes of drones, such as unmanned air vehicles, micro air vehicles, Nano air vehicles, Pico air vehicles, and smart dust. The maximum wingspan and weight of UAV is 61m and 15000Kg respectively while maximum wingspan and weight of Smart Dust is 1mm and 0.005gm respectively. All other types have capacities lying between this range. The sizing process of drones is usually composed of five steps: (1) defining the mission, (2) setting the flight mode based on the type, (3) determining the wing shape (planform) and aspect ratio, (4) constraint analysis, and (5) weight estimation. They also showed that, the endurance of rotary wings types of drones is restricted due to the required higher power for the hovering flight mode. There are many challenges in designing these drones when their size and weight are decreased. Applications of drones in security surveillance, for vegetation and for medical emergency, etc.

CONCLUSION

Thus, in this review we get to know about basic construction and working principal of a drone. Above studied research papers have focused on various factors like construction, performance, control, etc. of a multirotor. The data collected and studied from above papers is very useful while fabricating actual multirotor model and its testing. Selection of frame type, controlling elements and other important electronic components is the first step of drone building. Fire-fighting drones need more stability than any other application drones. We are going to use a hose pipe which will supply water from ground level, this kind of applications need extra stability in air while hovering. Considering extra stability, we decided to make hexacopter. Motor and propeller pair gives us the desired thrust, thus its necessary to check various pairs of motor and propellers considering required thrust and frame size. Required thrust can be calculated by using concepts of fluid mechanics. Static and dynamic weight of water column carried by hose pipe will play crucial role. For more stability flight controller must use various sensors like GPS sensor, gyroscope sensor, magnetometer sensor, barometer sensor, etc. Flight controller must be using advanced systems like fuzzy control or PID control. Big range of transmitter-receiver is available in market, we can use any of them which suits the application (no. of channels required). Flight time is also a major concern in case of fire-fighting drones. Flight time can be increased by either reducing weight of whole assembly or increasing battery capacity. But the increase in battery capacity increases the overall weight of assembly. Hence an intermediate battery capacity must be assigned which can give sufficient flight time with minimum weight.

According to related literature review, we will collect required data and will design and modified fire-fighting drone. The approach will be synthesis, design, development & testing of the machine. The various parameters such as design of frame, components specification, stability will be considered while making the fire-fighting drone.

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