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Design of Unmanned Aerial Vehicle (UAV) for Agricultural Purposes

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Abstract : *In the present age, there are a lot of improvement in precision agriculture for augmenting the crop productivity. Especially, in the developing countries like India, more than 70% of the rural people depends upon the agriculture fields. The agriculture faces striking losses due to the diseases. These diseases came from the pests and insets, therefore productivity of crops is attenuated. Pesticides and fertilizers are used to eradicate the insects and pests in order to enhance the crop quality. The WHO (World Health Organization) estimated as one million cases of ill effected, when spraying the pesticides in the crop filed manually. The Unmanned aerial vehicle (UAV) – aircrafts are used to spray the pesticides to avoid the health problems of humans when they spray manually. UAVs can be used easily, where the equipment and labors difficulty to operate. This paper reviews briefly the implementation of UAVs for pesticide spraying.Various parameters like temperature, humidity, rain, etc affect the production rate of crops. Which are natural factors and not in farmers control. The field of agriculture is also depends on some of factors like pests, disease, fertilizers, etc which can be control by giving proper treatment to crops. Pesticides may increase the productivity of crops but it also affects on human health. The Exposure effects can range from mild skin irritation to birth defects, tumors, genetic changes, blood and nerve disorders, endocrine disruption, coma or death. This research paper will show how UAVs can reduce human efforts in various operations of agriculture like spraying of pesticides, spraying of fertilizers, etc.*
Where dense and very tall rows of crops are in place it is difficult to quickly access centrally located crops on foot or by land vehicle without damaging some crops in the process, but these areas can be safely and rapidly over flown by light weight drone aircraft with no damage to crops.In this research paper we propose a design of the model, which will spray fertilizers and pesticides which can be controlled by remote controller. The model will be a Hexacopter UAV with spraying mechanism. The frame of Hexacopter will be made of Hollow Aluminium pipe with carbon fibre rods inside it which will make the frame light weight and the strength of frame will increase. The arms of Hexacopter are foldable hence the drone becomes compact in size. The spraying mechanism consist of a 2L tank, pump and 4 nozzles for effective spraying, resulting in convenience to the farmers

Keywords - *UAV, Spraying mechanism, Hexacopter, Frame, Tank, Nozzle, Pump.*

I. INTRODUCTION

The Indian Agricultural sector is the most important sector as it amounts to a astounding 18% of India's Gross Domestic Product (GDP) and also provides employment to 50% of the national human workforce. Our country is dependent on agriculture so much, has yet to tap into the real potential of agriculture, because of improper methods of monitoring crops and the irrigation patterns and the pesticides required to be applied. In India, there are over 35 drone start-ups that are working to raise the technological standards and reduce the prices of agricultural drones. This project aims to develop Unmanned Aerial Vehicle (UAV) for overcoming this problem and also spay large amounts of pesticides within smaller interval of time using hexacopter. India is a country whose economy majorly depends upon agriculture. Today, India ranks second worldwide in farm output. More research and development work are required to make remarkable growth in farming. In order to increase the productivity of agriculture pesticides are sprayed on crops for protection from insects. But its main disadvantage is that it affects the farmer's health while spaying these harmful pesticides. Hence the most effective and efficient way to surmount from this problem is now essential. Much more attention is required to reduce the cognitive factors which are faced by the farmers so that it will be ultimately advantageous for farmers and country development. One of the most important problem is regarding health of the farmers which arises due to coming in direct contact with pesticide while spraying on crops.

II. LITERATURE REVIEW

B.Balaji et al. [1] developed an hexacopter UAV with the purpose of spraying pesticides as well as crop and environment monitoring using Raspberry Pi that run on python language. Their UAV also contains multiple sensors like DH11, LDR, Water Level Monitoring sensors. From this experiment, they finally concluded that with proper implementation of UAVs in the agricultural field almost 20%- 90% savings in terms of water, chemical maltreatments and labor can be expected.

F.Sarghini et al. [2] studied that a powerful tool for a preliminary investigation of such interactions is provided by computational fluid Dynamics, allowing a predictive analysis of possible wash down wake effects with spraying operative setup. And in this work a CFD analysis of two different configurations (X6 and Y6 multirotors) is presented.Different design choices seem to have a consistent impact on the flow field embedding the drone, and CFD is A powerful tool to provide indications about possible collocation of auxiliary spraying or granular distribution Systems. The Y6 configuration seems to generate an increased downwash effect in 5 terms of extension but with reduced.Intensity, probably due to the interactions of counterrotating pairs of propellers. On the other hand, in such configuration a consistent disturbance is generated on three main directions 120° apart from the main axis of symmetry.

F.Veroustrate et al. [3] department of bioscience engineering university of Antwerp. Drones [3] advocates have cited precision agriculture crop management. Drones create the expectation of a large swing in the way we grow crops. Removes human error and especially helpful for nighttime monitoring due to humans eyes inability to see in a dark. The application list in this paper is bound to undergo quite some growth in the near future as more and more research takes place and will take place and certainly airspace will be opened for certified drone equipped agricultural service providers.

Huang et al. [4] made a low volume sprayer which is integrated into unmanned helicopters. The helicopter has a main rotor diameter of 3 m and a maximum payload of 22.7 kg. It used to require at least one gallon of gas for every 45 minutes. This study paved the way in developing UAV aerial application systems for crop production with higher target rate and larger VMD droplet size.

I.D.Pharne et al [5] mentioned a combination of Quadcopter and spraying mechanism. The spraying mechanism is connected to Drone which is programmed and by giving command it is operated. The batteries and Electronic speed controllers are used to control speed and other operation. The legs of drone have a '+' or 'x' arrangement. Hardware used: ATmega328- 8 bit micro controller with high performance and low power. BLDC motors- 3000 mAh, 25 C. ESC. LIPO battery- 3.7 V single cell, 3sp1. Radio receiver- 2.4 Ghz, 40 mA, 5 V. Accelerometer sensor. Gyroscope sensor. Frame- glass fiber frame.Software used: Multi wii. Arduino.BLDC higher flight capacity even if weight is increased. High rated LiPO Battery allow more flight time. This requires less capital cost. It also reduces the time require for spraying the pesticide on the crops.

etc. 6 and components such as motors. This drone was programmed for two modes that are manual mode and autonomous mode.

III. PROBLEM DEFINITION

Problem statement Studies on Unmanned Aerial Vehicle (UAV) has been very active in recent decades, because of rapid progression in design and flying technologies. This project aims at design and develop a drone mounted sprayer and evaluate its performance for application of chemicals/pesticides.

IV. METHODOLGY

The proposed methodology uses both observation and measurement methods and includes numerous methods such as expert opinions, focus groups, and content verification. It also involves sophisticated assessment of construct validity including substantive and structural aspects. The operating system can be seen as the spectrum of bulk of quantitative as well as quantitative methods. It contains an analysis of the body of methods and principles associated with the field of knowledge as the methods

used in the various regions vary depending on their historical development.

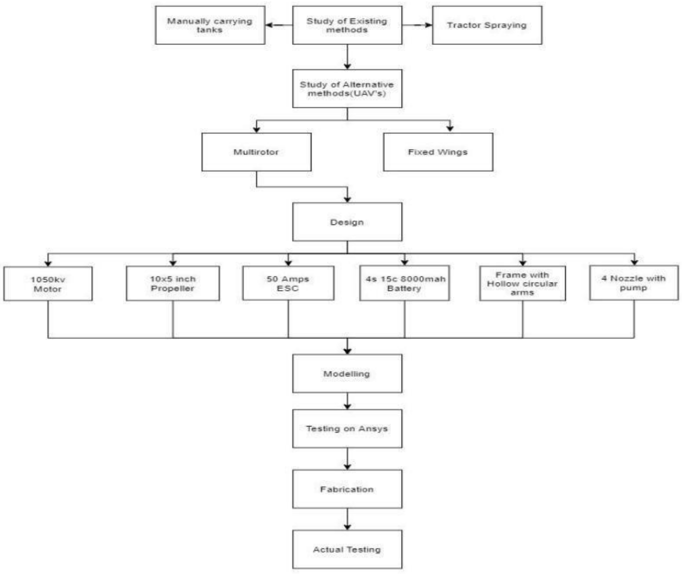

Fig 1 - Flow Chart of Methodology

V. DESIGN & CALCULATIONS

1. Motor

An electric motor is an electrical device which converts electrical energy into mechanical energy. The two types of motors generally used for drones are CW and CCW Motors. Elementary difference between CW and CCW motor is the prop shaft thread rotation. The goal is to use 2 CW motors and 2 CCW motors on a quad, so that when the motors spin, all four prop nuts lock themselves down.

Specifications:
Motor Kv: 1050 RPM/Volt
No-Load Current (Io): 1.6
Amps@10volts Max Continuous
Current: 36 Amps
Max Continuous Power: 570
Watts Weight: 116 Grams
Shaft Diameter:

LOAD TEST REPORT

Voltage/V	PROP	PULL/g	CURRENT/A	ESC
11.1	9*3.8 E	920	13.9	30A
11.1	9*3.8 SF	1040	16.8	30A
11.1	9*4.7 SF	987	18.1	30A
11.1	10*5 E	1400	25.3	40A
11.1	11*5.5 E	1630	28.9	40A
11.1	11*7 E	1580	31.2	50A
11.1	12*6 E	2040	38	50A
14.8	8*3.8 SF	1350	21.2	40A
14.8	8*3.8 E	1270	20.4	40A
14.8	8*6 SF	1480	30.7	40A
14.8	9*3.8 SF	1780	28	40A
14.8	9*3.8 E	1560	23	40A
14.8	9*4.7 SF	1590	23.4	40A
14.8	9*6 E	1850	34.3	50A
14.8	10*5 E	2160	41	50A

Fig 2 – Load Test Report Chart

2. ESC

Brush less motors are controlled by brush less ESCs, that are used on most Hexacopters. The maximum amperage an ESC can handle needs to be greater than the motor/prop combination will draw. In terms of ESC, suggesting 20%-50% extra Amps is good rule to ensure your ESC do not burn out.

Since our motor is of max current 42 Amp and we can take the esc of 50A.
Due to reason or formulae ESC (A) =1.2×MAX AMP OF MOTOR =1.2×42
=50.4 SO, we have chosen the ESC of 50A.

3. Thrust Calculation

3.1 Required Thrust (Without Spraying Mechanism)

General required thrust is given by an formula mentioned below it is Thrust required = (total weight of setup) ×2/4.

Therefore according to the frame, esc, battery and other set up we are getting a weight of 3000 grams. Required Thrust = 3000×2/4
= 1500 grams

Here we get the required thrust for each motor should be 1500 grams for each motor.

Now we have to calculate the actual amount of thrust that is going to produce by an individual motor. The thrust generated by motor is given by following formula

$T = [(eta \times P)^2 \times 2 \times pi \times r^2 \times air\ density]^{1/3}$

Where,

Eta = prop hover efficiency let us take it as 0.7-0.8

P = shaft power = voltage ×current ×motor efficiency R = radius of propellers in meters

Air density = 1.22kg/m³

Voltage = 10V

Current =36A

Motor efficiency =75%=0. 75 Eta=0.7

Then, thrust is

$T = [(0.7 \times 10 \times 36 \times 0.75)^2 \times 2 \times 3.14 \times 0.254^2 \times 1.22]^{1/3}$

= 26.03 N

Therefore Thrust calculated T = 26.03 N

= 26.03×0.101 Kg

= 2.63 kg

= 2630 grams

Hence, the thrust generated by each motor = 2630 grams

Since we have 6 motors in the hexacopter, the total thrust generated by all motors is given by multiplying, thrust with 6

Total thrust T = 2630×6 grams

= 15780 grams

= 15.78 kg

If we again choose any less efficiency in motor then we will take some factor of safety, if they work only70% efficient in the above 70% efficient work we can produce thrust of Thrust

T = 15.78×70/100 T = 11.046 kg

Therefore the min to min amount of thrust produced by all the motors is 11.046 kg

3.2 Required Thrust (With Spraying Mechanism) It will be given by

T2= (weight of drone +weight of spraying mechanism)×2/4 T2 = (3000+2000) ×2/4

T2 = 2500 grams

Since the thrust produced by individual motor is 2630 grams, that thrust is greater than the amount of thrust required with the combination of drone and spraying mechanism, so our system will be in safe condition and work effectively.

4. Propeller

Since the thrust required is 2500 grams, as we calculated above thrust produced or generated by each motor is 2600 grams. The system will be safe and run without any defect.
Finally we have concluded to select the 6 propellers of size 10×5 inch which 3 are supposed to CW and other 3 for CCW.

5. Battery

We have to calculate the amount of energy it is consuming; hence we have now calculating the source required by the battery.

Max source = discharge rate*capacity
= 15×8000
= 120000 = 120 Amp

6. Frame

Frame type - Hexacopter

If a motor or propeller is broken-down, a hexacopter is able to fly and land safely even with 5 rotors. 6 rotors are used for a more stabilized flight behavior. Flying even at high wind speeds. Higher load capacity. 6 motors are used for more thrust and power.

Material used – Aluminium

Aluminium is an highly versatile metal and has number of advantages, it both lightweight and flexible. Aluminium is corrosion resistant and has good thermal conductivity.

For arms hollow aluminium pipes of circular cross section are used. Since, circular cross section gives minimum drag force and negative thrust compared to Rectangular, Triangular, T-section and I- section. Aluminium rods enable the motor to disperse the heat faster. Inside these arms carbon fiber rods are fitted. This is done to trim down the overall weight of the drone, also the carbon fiber rods provide the firmness required to bear the thrust force.

These arms are fold able which reduces space and makes drone portable. Fork joints are used to fold these arms.

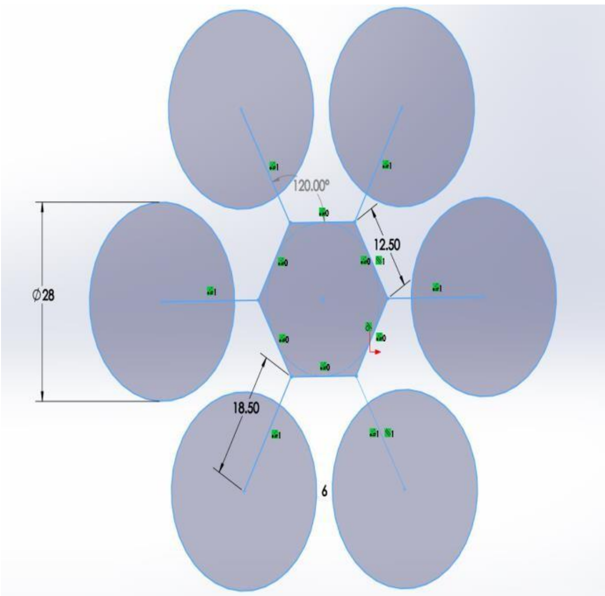

Fig 3 – 2D Design

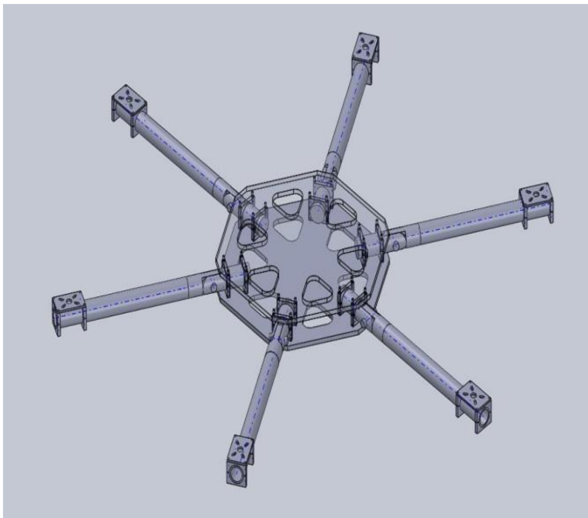

Fig 4 - 3D modelling on SolidWorks

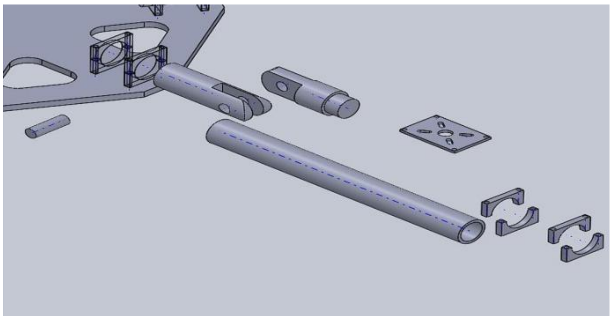

Fig 5 – Arm Assembly

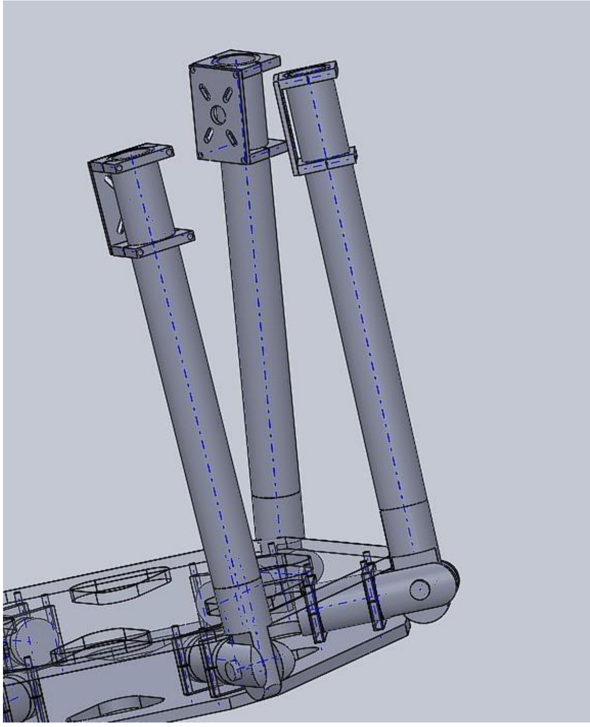

Fig 6 – Folded Arms

VI. CONCLUSION

We have delineated a design of unmanned aerial vehicle (UAV) mounted spraying mechanism for Agricultural purpose and for spraying germicidal. This technique of spraying pesticides on Agricultural fields reduces the amount of labours, time, cost and the risk concerned with the personnel involved in spraying the liquids. This Hexacopter can also be used in spraying disinfectant liquid or sanitizer over buildings, water bodies and highly inhabited areas.

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