Design and Manufacturing of Unmanned Aerial Vehicle for Spray Painting

[1]Nilam R. Rajmane, [2]Jyoti R. Thombare, [3]Mayuri S. Salunkhe, [4]Prajyot P. Godse
[1,2,3,4]Dnyanshree Institute of Engg. and Technology, Satara, Maharashtra, India

Abstract

The hexacopter spray paint pump which is used for paint the wall. This principle is used for high altitude buildings, with the help of hexacopter. The hexacopter is used for lifting purpose, in that rotary motion has shaft which is connected to propeller can be converted to the upward thrust which lift our equipment, also it has high speed brushless DC motor, spraying pump is working on this principle of rotary motion. This is used for spraying color paints. Six high speed torque DC motor utilizes battery power for working. Because of rotation of blades thrust is produced because air suppression from upward to downward direction, propeller blades are connected to DC motor shaft. Hence equipment get lifted for spray painting we can use liquid spraying pump.

Keywords

UAV; Remote Controller; Hexacopter; Brushless Motor; Reduce Efforts

I. Introduction

Building and construction are important industries around the world. In Day to day life construction industry is also developing expeditiously. the labor in the construction industry are not sufficient. Applications and activities in the early 90's aiming to upgrade equipment operations, improve safety, modify concept of workspace and furthermore, ensure quality environment for building occupier.

After the advances in the robotics and automation the construction industry has developed very fast. The advances in the robotics and its wide spreading applications, painting is also considered to be the tough process & it also has to paint the whole building. To make this work easier, and also to reduce the number of labors the remote operated spray painting machine was introduced.

Because of painting chemicals, hazards to the human painters such as eye and respiratory system. Also the nature of painting that requires recast the work and hand rising makes it tedious, time and effort consuming. These factors which inspire the development of remote operated UAV system for spray painting.

Drone means fixed wing airplanes or more commonly hexacopter and other multi bladed small helicopters. UAV is driven by an aerial vehicle which is operated to fly independently. The driving medium is one type of small representation Unmanned Aerial Vehicle (UAV).

A. Problem statement

It is really impossible to achieve perfect work in the whole painting processes. Some problems arising from men, machines, methods and materials. So, improve the process is by minimizing the problems as low as possible. The studies are which use in the process and propose a new method that can overcome those problems. An experimental of an automotive paint sprays will be conducted with some parameter focused on the flow visualization using experimental method. The time utilization for spray painting is maximum to reduce this problem the atomized spray painting will be used. Painting high altitude building is cumbersome work.

B. Objectives

1. To minimize human efforts the UAV system is operated by remote control.
2. To reduce time requirement for painting, spray nozzle is used.
3. To improve safety by eliminating work on scaffolds.
4. To control the wastage of paints.
5. To make machine structure.
6. According to this vision of painting we are create or we want to do some remedies on that problem
7. So we make a particular device which very useful for painters for reduce their efforts.
8. With the help of this drone there are no necessary to actual going on high altitude buildings, we can easily handle and operate all the things with less efforts.

C. Methodology

When design and performance in Unmanned Aerial Vehicle are similar to manned aviation, Unmanned Aerial Vehicle designers do not have to take an onboard pilot into account. This gives the Unmanned Aerial Vehicle's the advantage of reduced drag & weight (due to the elimination of the cockpit) as well as the ability to sustain a greater amount of gravity forces, allowing more complex flight management. Improvement in navigation and also the sensor advanced telecommunications technologies permit control at high altitudes over considerable distances. Technologies have made Unmanned Aerial Vehicle platforms more reliable in terms of flight control and hexacopter is an aircraft without a human pilot on board. This can be cotrolled through the remote by an operator on the ground.

D. Specifications

Weight	3 KG
Length of Arm	32 cm
No. of Arms	6

Model	**MTI806-2280KV (Brushless Motor)**
Supply voltage	11.1V
Operating current	10.6 A
Operating Speed	1300 rpm/volt

Model	**FSCT6B 6CH (Remote Controller)**
Frequency	2.4 GHZ
Transmitted power	0.8 W
Operating Range	1 KM

ISSN : 2249-5762 (Online) | ISSN : 2249-5770 (Print)

Model	Atmega328 (Arduino UNO M/C)
Operatng Voltage	5 V
Input Voltage	7-12 V
Crystal Frequency	16 MHZ

Model	ELFA1040(ESC)
Output Power	10-25
Maximum current	40A
Weight	62gm

E. Platform used

Proposed platform tools: - [material/hardware and/or software mention specified platform/tools Mention specified platform/tools needed with availabity]

SR. NO	PLATFORM/TOOLS	AVAILABILITY	
		IN CAMPUS	OUT OF CAMPUS
1.	CATIA V5 R19	-	YES
2.	ANSYS	-	YES
3.	SOLID WORKS	YES	-

II. Literature Review: References

In this couple of month we spend searching topics for project work we came across the Unmanned Arial Vehicle that is drone, as described in various journals and magazines as well as over the internet as follows.

The reference paper Quad copter Design and Implementation [2012] by Goponov. We get The design, implementation of quad rotor helicopter system. The class which is intended to provide the students with both theoretical and practical knowledge in the areas of mechanical engineering and design, system integration, hardware programming, and control system design and implementation. From this reference paper.

The reference paper Simple GUI Wireless Controller of Quadcoptert [2013] by D. Hanafi we get The development of remotely operated Quad copter system. This Quadcopter is controlled through a Graphical User Interface (GUI) where the communication between GUI and Quadcopter is constructed by using wireless communication system. From this reference paper. All signals from sensors are processed by Arduino Uno microcontroller board and output from the Arduino Uno microcontroller board is implemented to control Quadcopter propellers.

The reference paper Design and fabrication of remote operated 3-axis spray painting machine [2016] by Prof. Dinesh B. Shinde, Sanket D. Ingole, Rohit P. Gomase we get the refrences like The development of remotely operated spray nozzle has made painting operatation completed gracefully. In this paper, the concept of remote operated wall painting robot is described consisting of an electric spray gun that paint the walls vertically and is fitted on a movable robot base to give the linear feed motion to cover the painting surface.

The references paper Design of an Autonomous Wall Painting Robot b Mohamed Abdellatify, we get Wall painting is very repetitive, exhausting and hazardous process which makes it an ideal case for automation. Painting of an automated in automotive industry but not yet for the construction industry.

B. Motivation

Now a days skilled labour scarce for painting tall buildings. Also cost involved in constructing scaffoldings is high. For easier operation, painting high altitude buildings and minimize the problems such as unavailability of painters, danger involved in climbing scaffolding we are designing and developing UAV for spray painting. An estimates 2.3 million construction workers or 65% of construction industries work on scaffolds. In a recent BLS(burue of labor statistics) studies in 72.% labors injured in Construction sites.

III. Design of Hexacopter

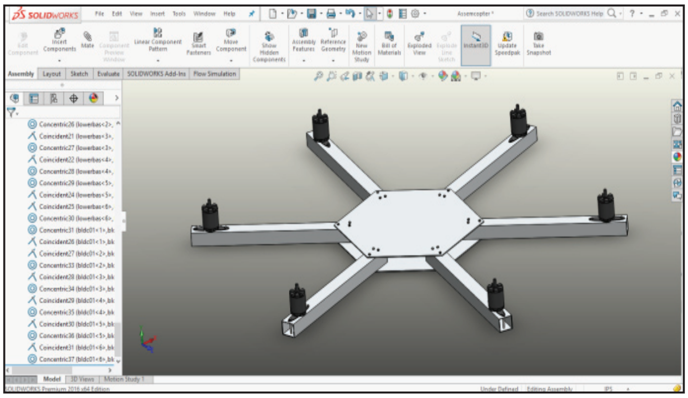

Fig. 1:

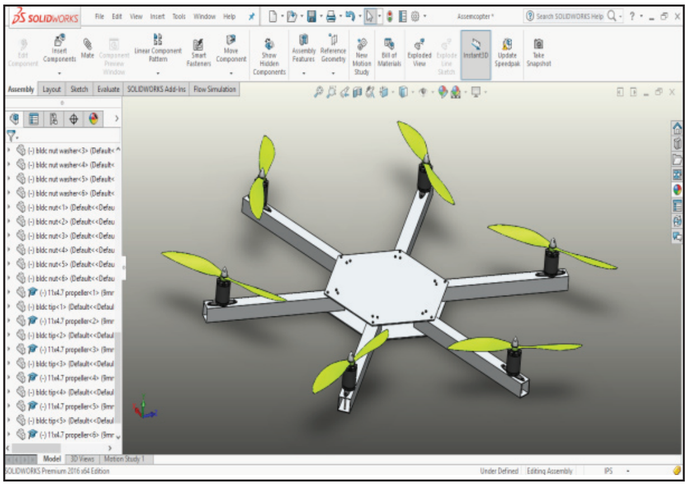

Fig. 2:

B. Propeller Thrust

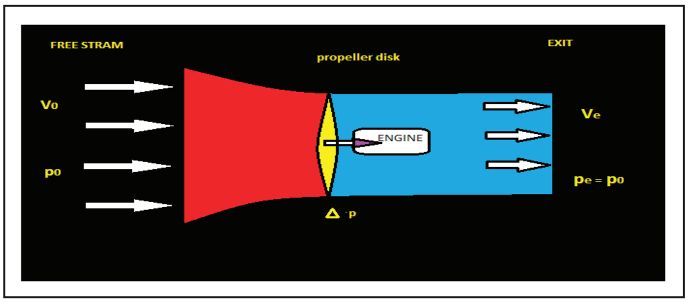

Fig. 3: Propeller Propulsion System

$Pt0 = p0 + 0.5\rho V^2 0$
$Pte = p0 + 0.5\rho V^2 e$
ρ = Density
p = Pressure
V = Velocity

Thrust = F = $A\Delta p$; $\Delta p = pt_e - pt_0$;
$\Delta p = 0.5\rho\ (V^2\ e\text{-}V^2\ 0)$
$F = 0.5\rho A\ (V^2\ e\text{-}V^2 0)$

C. Balancing of Chasis

Sum(fi)= m.g <=>hover
Sum(fi)<m.g<=>decline

1. Ascending

6.F>m.g
6.F =m.g
6.F<m.g

2. Descending

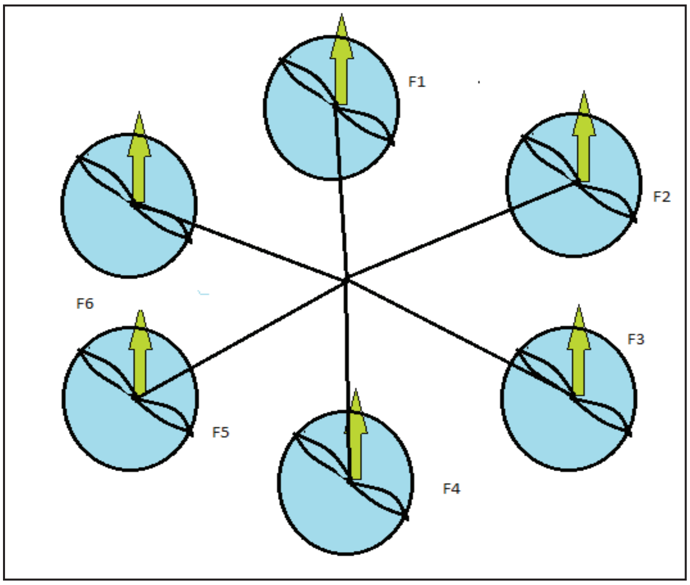

Fig. 4: Balancing of Chasis

D. Analysis Data Sheet

Analysis Data Sheet

DYS2830 1300KV, 3S (Full power test)					
Propeller	Thrust (g)	Current (A)	Voltage (V)	Power(W)	Efficiency (g/W
GWS 8040	760	13.77	12.2	168.0	4.52
Gemfan 8040	932	20.22	12.08	244.3	3.82
Gemfan 9060	1100	28.66	11.9	341.1	3.23

DYS2830 1300KV, 3S (300g test)					
Propeller	Thrust (g)	Current (A)	Voltage (V)	Power(W)	Efficiency (g/W
GWS 8040	300	3.83	12.38	47.4	6.33
Gemfan 8040	300	4.22	12.37	52.2	5.75
Gemfan 9060	294	3.91	12.34	48.2	6.09

Fig. 5: Analysis of Data Sheet

E. Basic Terms of Propeller

1. Radius(r):

It is the distance of the blade tip from centre.

2. Chord Length(c):

It is the straight line width of the propellar at given distance along the radius. Depending on the design of the propeller, the entire radius,or it may vary along the radius of propeller.

3. Twist angle(β):

It is the local angle of the blade at a given distance along the radius.

4. Pitch:

Pitch is the distance (in inches or millimeters) that a propeller section will move forward in one revolution. Pitch distribution is the gradual twist in the propeller blade from shank to tip.

5. Angle of attack:

Thrust produced by a propeller,in the same way as lift produced by awing determined by the blades angle of attack. It is the acute angle between the chord line of propeller blade and the relative wind. Angle of attack relates to the blade pitch angle, but is not fixed angle. It varies with forward speed of the equipment and the RPM of the propeller.

F. Factors Affecting on the Propeller

1 Centrifugal Force

Centrifugal force puts the greatest stress on a propeller as it tries to pull the blades out of the hub. It is not uncommon for the centrifugal force to be several thousand times the weight of the blade. For example, a 10 kg propeller blade turning at 2700 RPM may exert a forces of 50 tones on the blade root.

2. Thrust Bending Forces

Thrust bending force attempts to bend the propeller blades forward at the tips, because the lift toward the tip of the blade flexes the thin blade sections forward. Thrust bending force opposes centrifugal force to some degree.

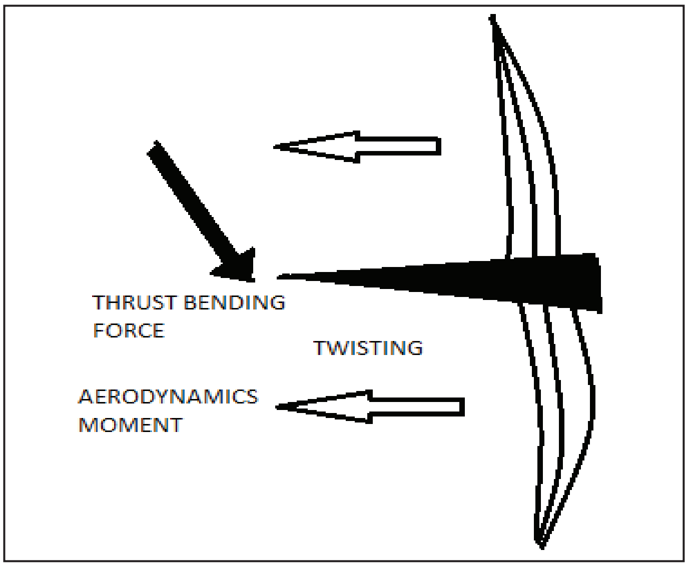

Fig. 6: Thrust Bending Forces

Aerodynamic twisting movement tries to twist a blade to a higher angle. This force is produced because the axis of rotation of the blade is forward of this axis. This force tries to increase the blade angle. Aerodynamic twisting moment is used in some designs to help feather the propeller. Axis of blade location Center of pressure aerodynamic twisting force

3. Centrifugal Twisting Movement

Centrifugal twisting movement tries to decrease the blade angle is produced since all the parts of a rotating propeller try to move in the same plane of rotation as the blade centerline. This force is

 ISSN : 2249-5762 (Online) | ISSN : 2249-5770 (Print)

greater than the aerodynamic twisting moment at operational RPM and is used in some designs to decrease the blade angle.

4. Vibrational Forces and Resonance

When propeller is producing thrust, aerodynamic and mechanical forces are preset which cause the blades of the propeller to vibrate. A person designing a propeller must take this into consideration. If this is not done, these vibrations may cause excessive flexing, hardening of the metal and could result in sections of the propeller braking of during operation. Aerodynamic forces have a great vibration effect at the tip of the blade where the effects of tansonic speeds cause buffering and vibration. The most critical location when looking for stresses is about 2.5 cm from the propeller tip some combinations are sensitive to certain RPM ranges. If it is operated in the critical range over period of time, there is strong possiblity that the propeller will suffer from structural failure due to vibrational stresses.

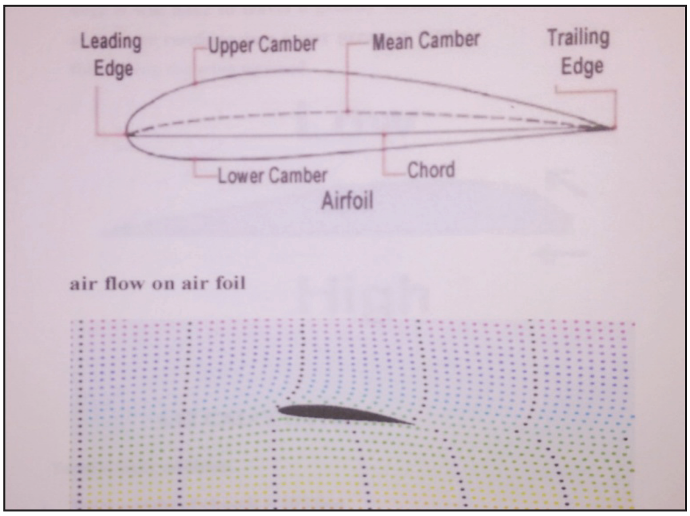

Fig. 7: Air Foil

G. Design Procedure of Propellers

The design parameters of propellers are
1. The number of blades.
2. The axial velocity of the flow.
3. The diameter of the propeller.
4. The desired thrust or the available power of shaft.
5. The density of medium. (air : 1.22 kg/m^3)
6. The number of blades:

The number of blades 'has a small effect on the efficiency only. Usually a propeller with more blades will perform slightly better, as it distributes its power and thrust more evenly in its wake. But for a given power or thrust, more blades also mean more narrow blades with reduced chord length, so practical limit have to consider here. The chord length can be increased while decreasing the diameter to keep the power consumption constant.

7. The axial velocity: The velocity of the incoming iluid together with‘ the velocity of rotation determines the pitch distribution of the propeller. Large pitch propellers may have a good efficiency in their design point, but may run into trouble when they have to operate at axial velocity. In case, the blades tend to stall. Usually the best overall propellers will have a pitch to diameter ratio in order of 1.
8. The Diameter of Propeller: The propeller diameter has a big impact on performance. Usually a larger propeller will have a higher efficiency, as it catches more incoming fluidand distributes its power and thrust on a larger fluid volume.
9. Density of Medium: The density has no infinenee on the efficiency a propeller, but affects the size and shape. The air has density of 1.22 kg/m^3
   By considering all these terms we are selected the blades 10*4.51 and 10*4.58

H. Technical Terms

1. Bernoulli’s Principle

This principle states that as the air velocity increase, the pressure decrease; and as the velocity decreases, the pressure increases.

2. Airfoil

Airfoil is technically defined as any surface such as an elevator, rudder, wing, main rotor blades designed to obtain reaction from the air through which it moves.

I. Electronics Part

A. Remote Controller

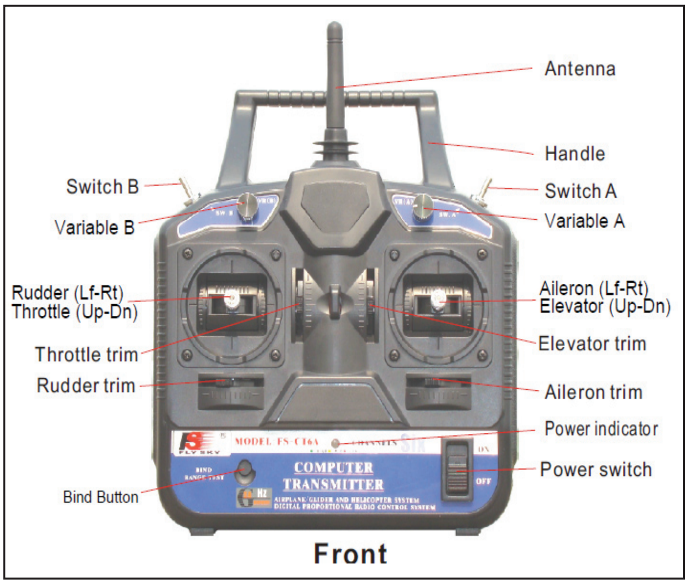

Fig. 8: Remote Controller

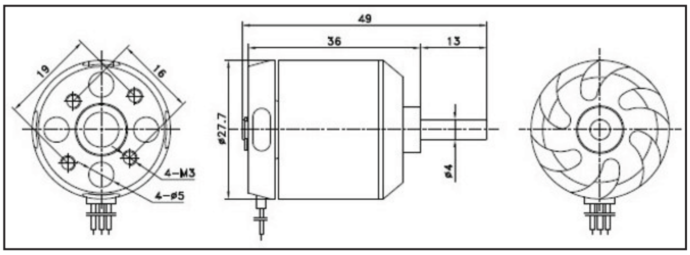

Fig. 9: Brushless Motor

IV. Finite Element Analysis of Propeller Blade in ANSYS-CFX

- To simulate working environment for single UAV propeller
- To check axial thrust generated by 1100kv motor with 12V supply

1. Mesh Model

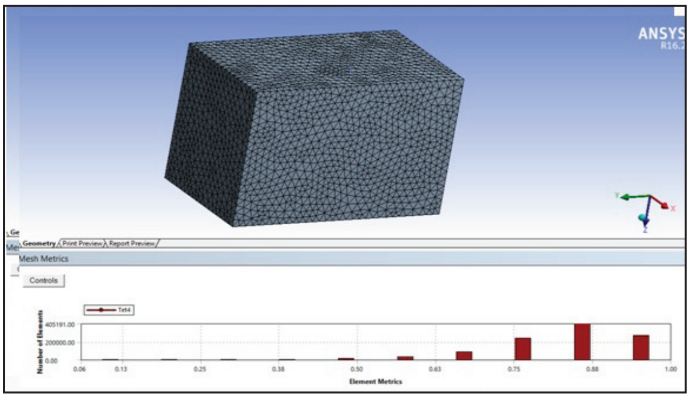

Fig. 10:

2. ANSYS Setup

- **Enclosure:** Box type
  - **Material:** Air
  - **Environment:** Stationary
- **Propeller:** 8/6 [8in length and 6in pitch]
  - **Material:** Carbon Fiber
  - **Environment:** 13200rpm
- **Analysis Type:** Transient
  - **Total Time:** 2s
  - **Time Step:** 0.1 s

A. Axial Thrust on Enclosure

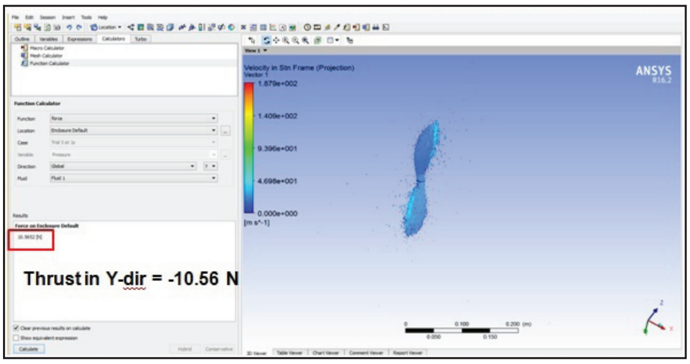

Fig. 11:

V. Result Conclusion

1. Axial thrust generated by single propeller in environmental condition [motor 1100kV and 12V battery] is = 10.56 N
2. Single propeller can carry approx. 1.07kg weight according to the simulation

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