Design Analysis of Hoverbike Prototype

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Abstract— Our main objective is to build a prototype of hover bike in order to get a transport facility. Primarily we are planning to work on basic body frame of our prototype. The intention of this project is to show the future evolution of transporting. Also it can be used for various field of application area surveillance, material handling, cattle mustering, movie industries, Military and Emergency Services. In this system, we will use electric power in order to get required thrust at the start of hovering. As per our research; major issue while hovering is to balance the entire weight of prototype. In our project we will apply a new concept of using 4 motors at a time to get a required thrust. Also we will incorporate the concept of overlapping propellers which reduces the entire weight and floor area. We will take some reduced ratio to the actual hover bike so our main aim is to design a prototype which will be in working condition.

Key words: Hoverbike, Prototype, Overlapping Propellar, Weight approximation, Thrust

I. Introduction

Transportation and military are the two focused areas for aerospace industry today. The transportation sector is focusing on designing larger, more efficient, and more reliable aircraft. The military focuses on designing of more effective, maneuverable, and deadly weapons. There is also a private sector in the aerospace industry. New helicopters, small single engine planes, and other unique flying devices all fall into this category. There are some other commercial applications that could benefit greatly from the hover bike.

A hover bike is basically a combination between a motorcycle and a helicopter. Ideally, this vehicle should allow people to explore the earth in a new and unique way. Properly designed hovercraft would be able to take off and land vertically, also it should move skillfully and carefully through complex spaces. Some test prototypes are in development but no commercial hoverbike has been built yet.

The Hover bikes are been designed from the very beginning to replace conventional helicopters for example the Robinson R22 in everyday one man operational areas like cattle mustering and survey. It is inefficient and dangerous to place complex conventional helicopters in harsh working environments. Commercial hoverbikes will be comparatively cheaper product which will not only take over the existing market but also can open it for more number of new customers who before could not afford the high cost of conventional helicopter. [2] [4]

Fig. 1: Bi copter Hover bike [6]

The original Hover bike as shown in above figure is with a maximum 270kg takeoff weight. It means that it can lift at most two men at a time.

A. Objective:

To design a prototype that will help in:-

- Surveillance, material handling, cattle mustering, movie industries and Military and Emergency Services.
- Search and rescue operations.
- To reach some areas inaccessible to road vehicles and helicopters.
- Carrying supplies if extraction is impossible.
- Rescuing people who fall through ice.

The response time would be much quicker than a helicopter, and could save many lives.

B. Invention of Hover bike:

The original Hover bike was built by Chris Malloy of New Zealand, after work and studies in his garage in suburban Sydney Australia. This project started out as a hobby, but quickly grew into a commercial enterprise, with interest from people and groups such as universities, farmers, search and rescue, private and military, with notable visits from the US Army G-3/5/7 and Locheed Martin “skunk works “Most of the frame of the original Hover bike was hand crafted from carbon fiber, Kevlar and aluminum with a foam core.

Fig. 2: First Hover bike [8]

First Hover bike prototype is a bi-copter. The vehicle is controlled by deflecting thrust from its two propellers using control vanes – these are a bit like rudders or ailerons on a plane. The bi-copter is an elegant solution and vehicle – however the available technology is not ready yet for a practical vehicle with a bi-copter design. The most noticeable feature of the new Hover bike and the 1/3rd scale drone is its unique patent pending offset and overlapping rotor blades, designed to reduce weight and planform area. Just like the manned vehicle, the ducting around the propellers is a safety feature, and the vehicle is lightweight and powerful, while folding to a compact size for transportation.

Fig. 3: Hover bike with overlapping propeller [9]

C. Specifications below are for the 'old' bi-copter hover bike:

Engine type: Flat twin 4-stroke, one camshaft and 4-valves per cylinder, central balancer shaft
Engine displacement: 1170cc
Nominal output: @7500rpm 80kw
Cooling: Air-cooled
Ignition: Electronic
Fuel system: Electronic intake pipe injection
Fuel tank capacity:
Without secondary tanks: 30l
With secondary tanks: 60l
Fuel burn: 0.5l/min / 30l/hr.
Fuel type: Regular unleaded
Drive-shafts: Custom carbon fiber
Gearbox: Custom 1.5:1 reduction
Propellers: 2 x oak with carbon fiber leading edge
Airframe: Carbon fiber with Kevlar reinforcement and foam core
Width: 1.3m
Length: 3m
Height: 0.55m
Dry weight: 105kg
Maximum takeoff weight: >270kg
Total thrust: >295kg
Range: Estimated 148km on primary tank
Altitude static hover: >9,800ft (estimated)

II. Methodology

A. Methods and techniques:

Selecting motor as a power source to propel as these energy efficient, environment friendly. Also it is suitable to the prototype considering size and weight. According to the motor specifications we will select the design control system for manual and wireless control. Which includes circuit board, controller, ESC (Electronic speed controller).

B. Design of Model:

There are two options for making a model which are modelling on solidworks or direct fabrication. We decided to make a virtual model in solidworks software and to analyze it for different factors like material, weight, thrust etc. before actual fabrication of the prototype.

III. Designing Factor

A. Factors considered for Frame design:

- Body shape: Shape should be aerodynamic to decrease the drag offered by air. It should cover less floor area.
- Housing for motor and propellers: housing should be of low weight. Selecting aluminium as a material for housing.

B. Factors considered for propeller design:

- Number of blades: The lower the more efficient the propeller is. We are using two blade propellers for our prototype as it gives plenty of area for lift and keeps it an efficient design at the same time.
- Material: Nylon fiber propellers for more efficient working
- Size: Propellers are classified by length and pitch. Increased propeller pitch and length will draw more current. Propellers with too high pitch will require more power. We select 9”X4.7” propeller i.e. 9 inch long and with pitch of 4.7 inch.

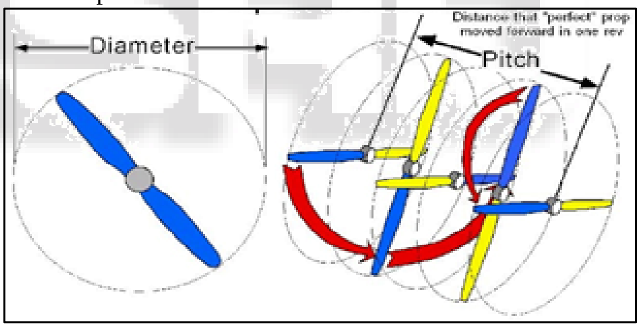

Fig. 4: Pitch of propeller [7]

C. Factors considered for motor selection:

- High speed operation
- Responsiveness: Quick acceleration
- High reliability [1]

IV. Technical Specifications

A. Main components:

Name	Specifications
Bldc Motor	1200 Kv
Propeller	Nylon Fibre Of Size 9” X 4.5”
Flight Controller	Kk 2.1
Transmitter And Receiver	Fs-Ct6b , 6 Channel
Bullet Connectors	3.5mm
Lithium Polymer Battery	11.1 V , 2200mah
Electronic Speed Controller	30 Amps , 12.6 V

Table 1: Specifications of main components [5]

B. Mechanical components:

Main body frame:
Material: Wood (ρ = 510 kg/m3)
Approx. volume = 0.0009 m3
Weight: 0.5 Kg (Approx)
Propeller casing
Material: Aluminum (ρ = 2700 kg/m3)
Approx. volume = 0.000037039 m3
Weight: 100 gram (Approx)
WEIGHT APPROXIMATION
4 motors weight = 4*80 = 320grams
Battery = 200 grams
4 esc = 4* 23 = 92 grams
Aluminium rings = 400 grams
Body = 500 grams
Miscellaneous= 500 grams
Total weight = 1912 grams around 2kg

V. ANALYTICAL METHOD

Calculations of static thrust are needed in order to ensure that the proper propellers and motors have been selected. Static thrust is defined as the amount of thrust produced by a propeller which is located stationary to the earth. This calculation is particularly important for this project because hover bike is more likely to perform at low speeds relative to the earth. This low-speed performance ensures that the calculations of static thrust can be applied to a wide range of flight conditions. Also, it is important to note that the final calculations of static thrust are estimates and not actual values.

The first step in calculating static thrust is determining the power transmitted by the motors to the propellers in terms of rpm. [3]

Power = Prop constant*rpm power factor (1)

Where,
Prop constant for Propeller of size 9 x 4.5” (power coefficient) = 0.090
D=0.2286m
Mass= 1 kg (total weight /4)
Power factor =3.2
Ideal rpm= 4189
Using eq. (1)
P =0.090*4.189^3.2 = 8.81w

The next step is to determine the thrust produced by a propeller. Equation 2 gives thrust based on the Momentum Theory.

$$T = \frac{\pi}{4} D^2 \rho v \Delta v \qquad (2)$$

T=thrust [N]
D=propeller diameter [m]
v=velocity of air at the propeller [m/s]
Δv=velocity of air accelerated by propeller [m/s]
ρ = density of air [1.225 kg/m³]

A commonly used rule is that velocity of the air at the propeller is v=½Δv of the total change in air velocity: Therefore, and equation 3 is derived.

$$T = \frac{\pi}{8} D^2 \rho (\Delta v)^2 \qquad (3)$$

Equation 4 gives the power that is absorbed by the propeller from the motor. Equation 5 shows the result of solving equation 4 for Δv and substituting it into equation 3. In doing so, Δv is eliminated and torque can be calculated.

$$P = \frac{T \Delta v}{2} \Rightarrow \Delta v = \frac{2P}{T} \qquad (4)$$

$$T = \left[\frac{\pi}{2} D^2 \rho P^2 \right]^{1/3} \qquad (5)$$

Where,
D=0.2286m
P=8.81w
Calculate T=1.98 kg

We select BLDC motor of 1200kv because it gives maximum thrust of 2.2 kg and weighs only 160grams. It has pretty good electrical efficiency because of its precision built and high quality parts. It is best suited for large size Quad rotor (quadcopter), Hexacoptors, Octocopter etc. Its rotor shaft is made up of hardened steel and supported by sealed dual bearings. It comes with propeller mount with 8mm diameter. Suitable propeller for this motor is 9 x 4.5”.

According to standards 1200kv brushless motor gives maximum thrust of 2.2kg
Therefore total thrust = 2.2*4 =8.8kg

VI. ANALYSIS IN SOLIDWORKS

A. Solidworks Model:

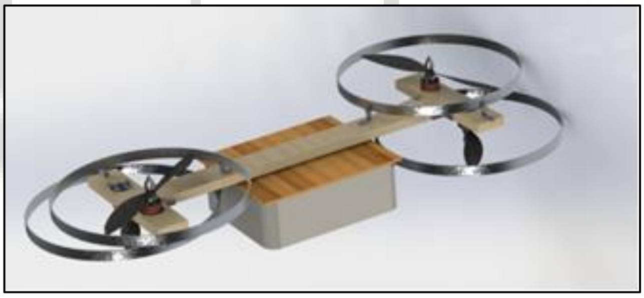

Fig. 5: 3D Model of prototype

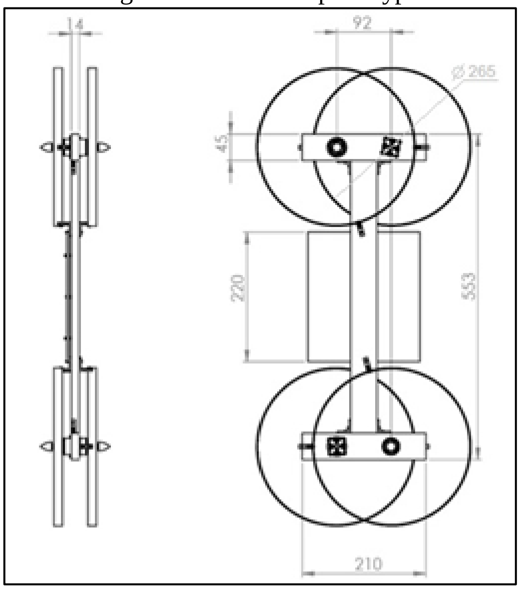

Fig. 6: Assembly drawing

B. Calculation of mass properties:

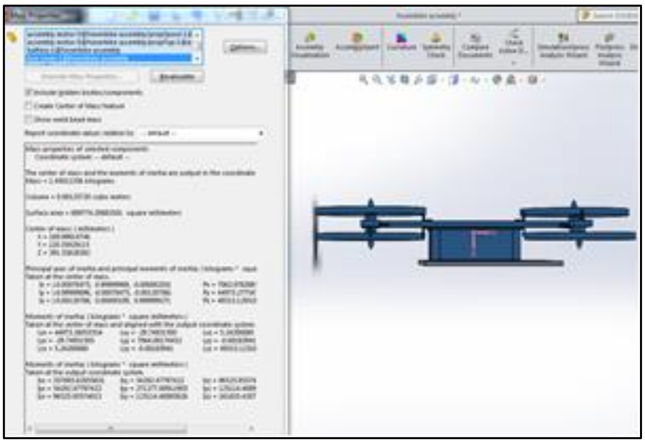

Fig. 7: Mass properties

Mass = 1.45011356 Kg

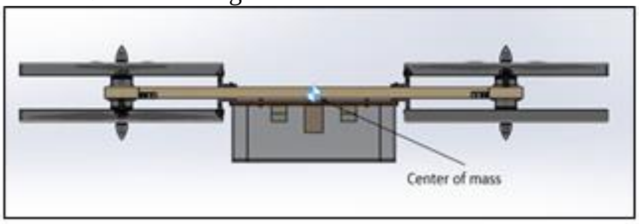

Fig. 8: Center of mass

C. Velocity analysis:

Apply the flow of air of velocity 10 m/s.

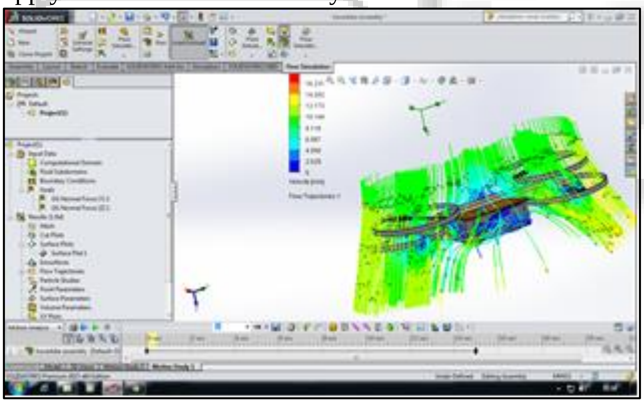

Fig. 9: Velocity analysis

D. Pressure analysis:

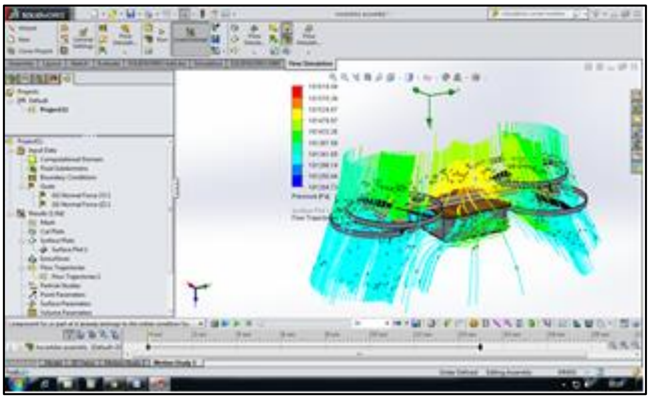

Fig. 10: Pressure analysis

E. Flow analysis:

- Make 4 rotating regions around 4 propeller
- Apply a control volume of air.
- Give rpm of 8000 to each 4 rotating region
- Set the surface and global goals
- Solve and load results of project.
- Take readings.

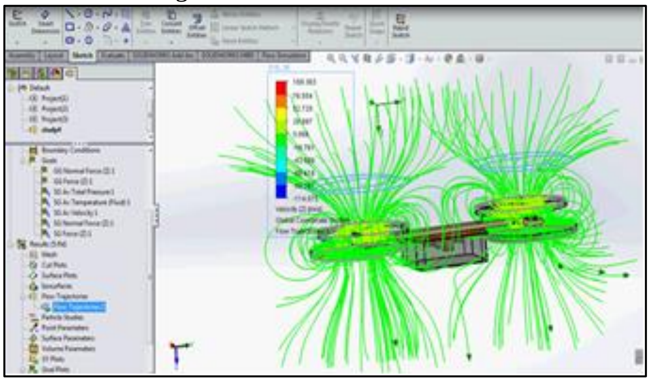

Fig. 11: Flow analysis

Goal Name	Unit	Value	Averaged Value	Minimum Value	Maximum Value
SG Av Total Pressure 1	[Pa]	102886.41	102781.88	102501.26	103168.84
SG Av Temperature (Fluid) 1	[K]	293.51766	293.37700	293.11258	293.51766
SG Av Velocity 1	[m/s]	52.490369	52.490369	52.490369	52.490369
SG Normal Force (Z) 1	[N]	-38.883442	-46.721295	-51.560823	-38.281896
SG Force (Z) 1	[N]	-38.875888	-46.71417	-51.559875	-38.275034

Table 2: Result of flow analysis

VII. CONCLUSION

Our paper is based on a concept of flying machine which is a revolution in aviation. Hoverbike is similar to helicopter but can be manufactured in less cost and much more compact in size. This paper is design and analysis of a prototype with approximate 1:12 ratio to the existing hoverbike. Theoretically the prototype can carry a weight up to 8.8 Kg (Approximate) including its self-weight, means it can lift up to 6.8 Kg (Approximate).

Original hoverbike uses IC engine as a power source but we are proposing electric energy as a power source. So there is a contribution towards pollution control. The only disadvantage will be its high initial cost.

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