Study and Design of Fuselage and Tail of a Solar Powered Flapping wing Ornithopter

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Abstract

The objective of this paper is to study and design fuselage and tail of a solar powered ornithopter which is capable of short separation flight. Ornithopters can be more productive, financially savvy and naturally benevolent in contrast with settled wing airplanes. In this study, renewable energy in form of solar energy is utilized for its functional operations of mechanical components. The software used for designing and analysis of fuselage and tail are Pro-e and MATLAB.

1. INTRODUCTION

Winged animals can accomplish close vertical departure, perform light-footed powerful moves, fly at rather moderate speeds, and utilize natural conditions by means of astute fluttering, taking off, and skimming in an exceptionally vitality productive way. Aerodynamics of flapping wing flight was observed and examined by means of an analytical model and numerical simulation, and approved through physical experiments. With high mobility, a large range of possible speeds, and reduced power requirements, ornithopters may be a reasonable and appealing method of transportation that merits more committed research and useful acknowledge. Fruitful hovering at zero speed was recently achieved with small hummingbird robots (Dashevsky, 2011) and a new generation of insect-like Micro Aerial Vehicles (MAVs) (Shyy et al., 1999). This class of flyers may have practical application in knowledge, observation, and surveillance missions (Baek et al., 2011). Moreover, MAVs are also utilized to study the aerodynamics of biologically inspired flying (Paranjape, 2012).

2. LITERATURE REVIEW

Todd Reichert (2010) guided an ornithopter that he called Snowbird. This ornithopter was made utilizing the carbon fiber, balsa wood, and foam. The ornithopter could fly for nearly 20 seconds, flying 145 meters with a speed of 7.1 meters per second. Benjamin J. Goodheart (2011) examined the history and impact of ornithopters and their design, and investigated developments and future patterns of this uniquely inspired aircraft. Deisadze et al; (2013) analyzed the practicality of overwhelming naturally motivated robots fit for floating. Sensory motor control was totally talked about, as it is significant in the successful design and implementation of an ornithopter. Djojodihardjo et al; (2014) studied and analyzed basic Unsteady Aerodynamic Approach fusing remarkable highlights of viscous effect and leading edge suction. Parametric investigation was completed to reveal the aerodynamic characteristics of flapping quad-wing ornithopter flight and for similar examination with various selected simple models in the literature. A generic approach was adopted to understand and imitate the unsteady aerodynamics of biosystem that can be adopted in a simple and workable Quad-Wing-Micro- Air-Vehicle (QVMAV) model. Berdeguer et al; (2015) portrayed how fluttering wing examples can be utilized to improve ornithopter plans. The group made a proving ground that can be altered to discover the wing strokes that consider the most effective flight. Chen et al; (2016) plan, manufacture and test validation of the mid-size butterfly ornithopter. The wing fluttering system can bolster wings with a traverse of 565 mm and canflap the wings in a 120-degree go and at a recurrence of 5 Hz. A lift compel estimation and a molecule picture velocimetry explore were performed to approve the execution of the ornithopter.

3. FUSELAGE DESIGN

An Acrylic sheet of size 50 * 25cm. thickness of the sheet is 3 mm which we had taken depending upon the stiffness requirement. From a design standpoint view the main frame of the ornithopter is a shockingly straightforward segment. Since the flapping mechanism contained completely within the gearbox frame the main frame of the machine serves mainly to provide mounting locations for the rear wing mounts, electroWnic components, battery, and tail assembly. There are two possibilities to run with the frame design, either a single flat plate which relies on its own thickness for stiffness, or a three dimensional design made from much thinner material that gets its stiffness from the truss-like structure.

If the frame had to be very stiff the second option would make for a much lighter and stronger option, but in this case the frame really doesn’t have to be very stiff in all directions.

While the complicated structure is stiff and the battery location is easier, it is heavier and needs to add extra plate for gear mounting. Flat frame is vastly easier to design and fabricate and may even be lighter.

- Length of fuselage : 25-45cm
- For mounting location of gear shafts, motor, battery and other components different holes and locations are made in the fuselage.
- Material for fuselage : Acrylic sheet or FRP(Fibre reinforced plastic) sheet

Torque and Power Calculation

$P = 2\pi Tf$

$F_{Lift} = (0.09kg)9.8\frac{m}{s^2}$

$d_{Lift} = 0.03m$

$T = Torque = F_{Lift} d_{Lift} = 0.026Nm$

$f = frequency = 60Hz$

$P = 2\pi Tf = 9.98W$

*Assumes no mechanical loss and hovering flight, lift acting at d=3cm from wing shoulder

Motor Subsystem

Current Motor Choice:

1. Brushless DC nuvoDisc
2. Produces up to 30W of continuous power
3. Has ability to reach speeds up to 50,000 rpm
4. we need a worm gear to achieve desired frequency
5. Has 32mm diameter and weighs 26g

Battery

(1). 12 Volts to drive motor.

(2). >10 Watts to power motor, actuator, and RF control

Mass budget of 40 grams.

(3). Lithium-ion batteries have theoretical Power-to- mass ratio of 1.8 W/g

Have found several options, choice will be based on compatibility with other components and weight.

Flight control Subsystem

1. Subsystem components: Receiver, decoder, amplifier, and Antenna

2. Microprocessor: Programmable Interface Controller (PIC)

Antenna mass: 3g

Receiver mass: 8g

Processor: 2g

MATLAB PROGRAM for dimension calculation:

```
clc;
clear all;
t=0:1/360:1;
a=input('Enter the length of crank:');
b=input('Enter the length of connecting rod:');
c=input('Enter the length of wing element:');
d=input('Enter the vertical length of fixed element:');
n=input('Enter the rpm of crank:');
omega1=2*pi*n/60;
theta1=omega1*t;
theta2=asin((a*sin(theta1)+b-d)/c);
omega2=(a*omega1*cos(theta1))./(c*cos(theta2));
x=a*(cos(theta1).*cos(theta1).*sin(theta2))/c;
y=cos(theta2).*cos(theta2).*sin(theta1);
acceleration=a/c*omega1*omega1*(x-y)./(cos(theta2).^3);
theta1=180*theta1/pi;
theta2=theta2*180/pi
omega2=180*omega2/pi;
acceleration=180*acceleration/pi;
plot(theta1,theta2);
xlabel('Driver angle');
ylabel('flapping angle');
title('Graph between driver and flapping angle');
plot(t,omega2);
xlabel('time');
ylabel('angular velocity of wing');
title('graph time v/s angular velocity of wing');
plot(t,acceleration);
xlabel('time');
```

```
ylabel('angular acceleration of wing');
title('graph of time v/s angular acc');
```

Final dimensions ***:***

- Length of crank : 7mm
- Length of connecting rod : 40mm
- Length of wing spar and CR joint offset from hinge : 8mm
- Distance between wing spar hinge and crank hinge : 42mm
- Maximum flapping angle : $\cong$ 38°
- Minimum flapping angle : $\cong$ - 24°
- Total flapping angle : $\cong$ 60°

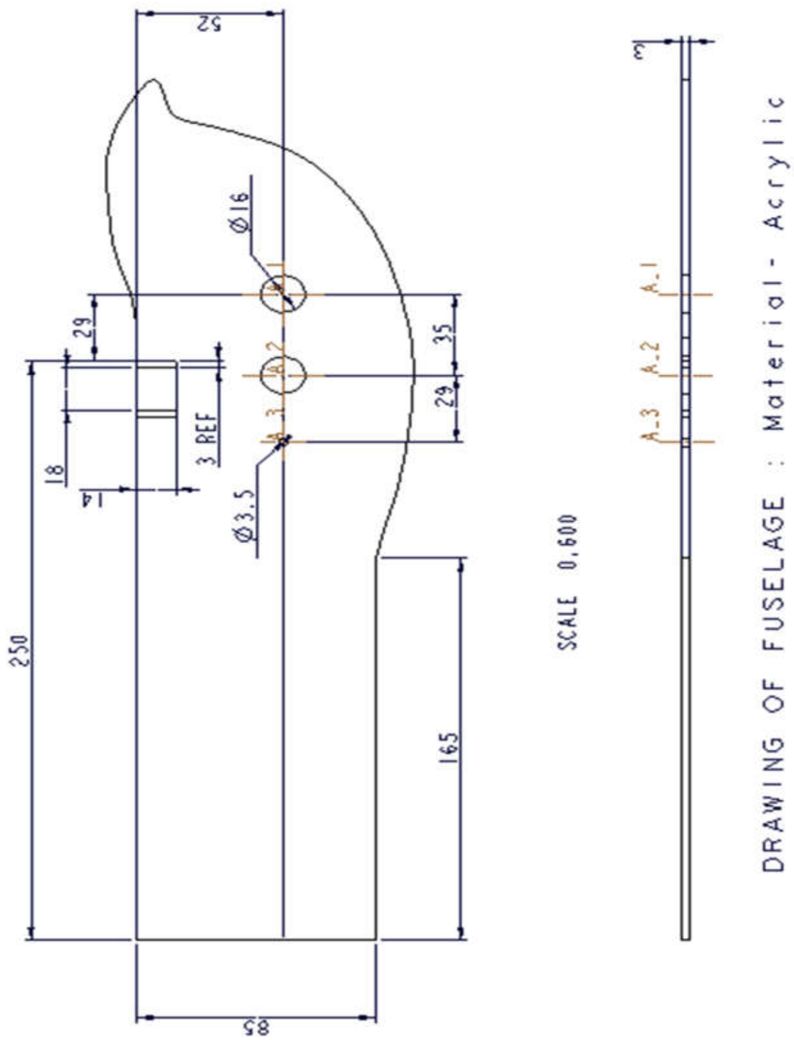

Figure: 1 Design of Fuselage

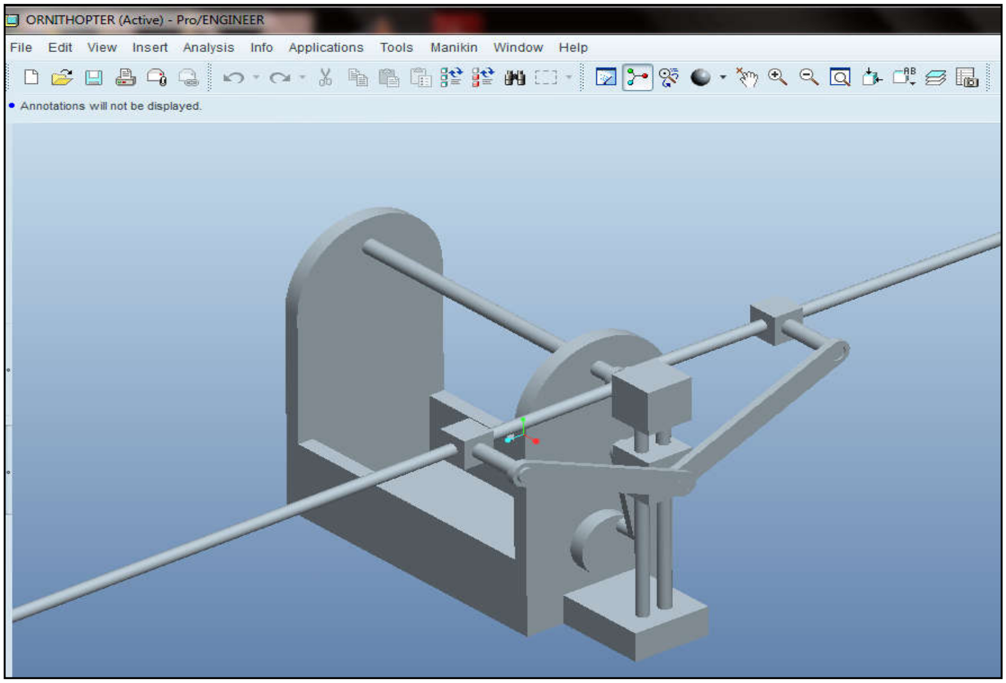

Figure: 2 Initial Ornithopter Design

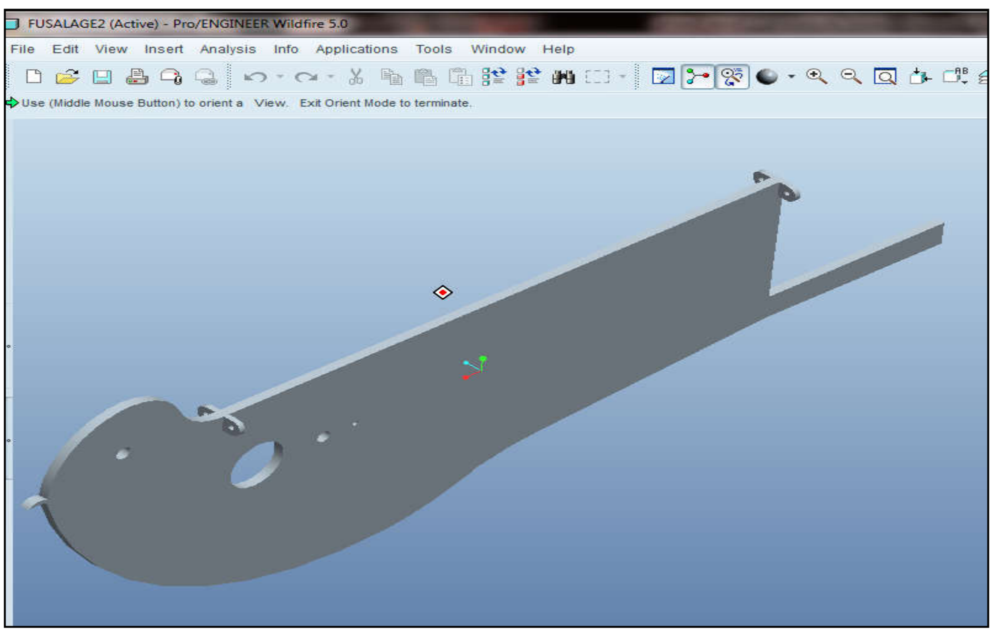

Figure: 3 New Ornithopter Design

4 TAIL DESIGN

Guiding is typically done by the tail. The wings can be utilized for guiding and controlling, but this is less consistently successful and more difficult to execute. A straightforward lift and rudder framework is exceptionally viable for ornithopter guiding. For a more birdlike appearance, however, a level, triangular tail is all the more regularly utilized. The tail may swing out to one side and right sides, so that the downforce of the tail causes a moving minute on the ornithopter. Alternatively, the tail may rotate about its long axis. In this case, the downforce is redirected in a way that provides yaw control. The ornithopter will have a horizontal stabilizer in the back. The tail generally gives a downforce to keep the nose up, and therefore the tail incidence relative to the wing is much more than you would find in an airplane. This angle is typically about 16 degrees.

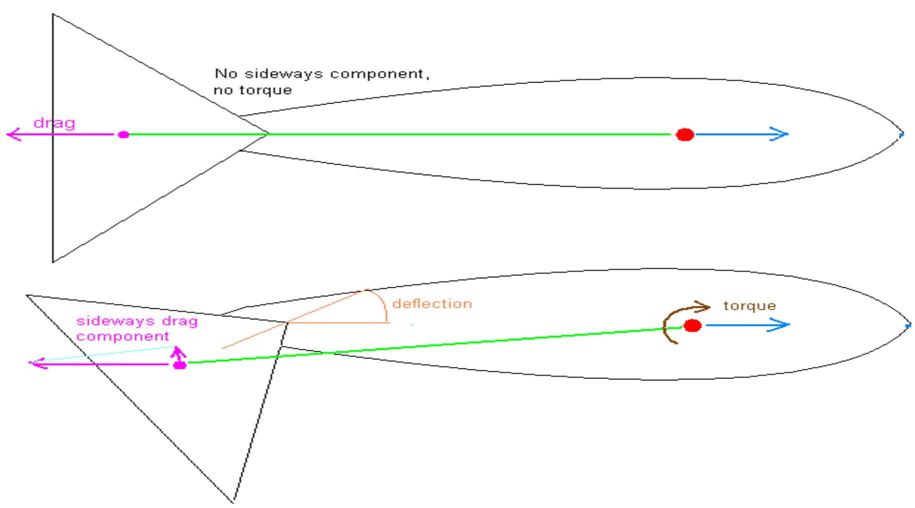

Figure: 4 Tail Mechanisms

Area of tail = 6-12% of main wing area

= $0.1*0.2\ m^2$ (wing area$\approx 0.5*l*b=0.5*1*0.2=.1$)

= $0.02m^2$

Position of tail = 1.5-3 * length of chord away from CG of ornithopter

= 2*0.2

= 0.4m

Dihedral angle of tail = 16°

For equilateral triangle shape of tale, size of one side = area $*4/\sqrt{3}$ = 16cm

5 GRAPHS

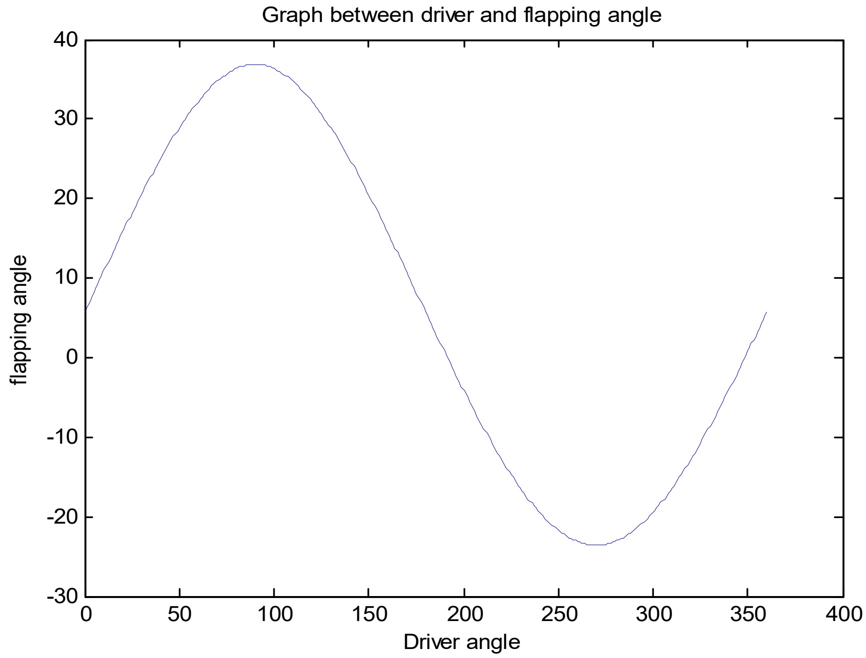

Figure: 5 Graph between driver and Flapping angle

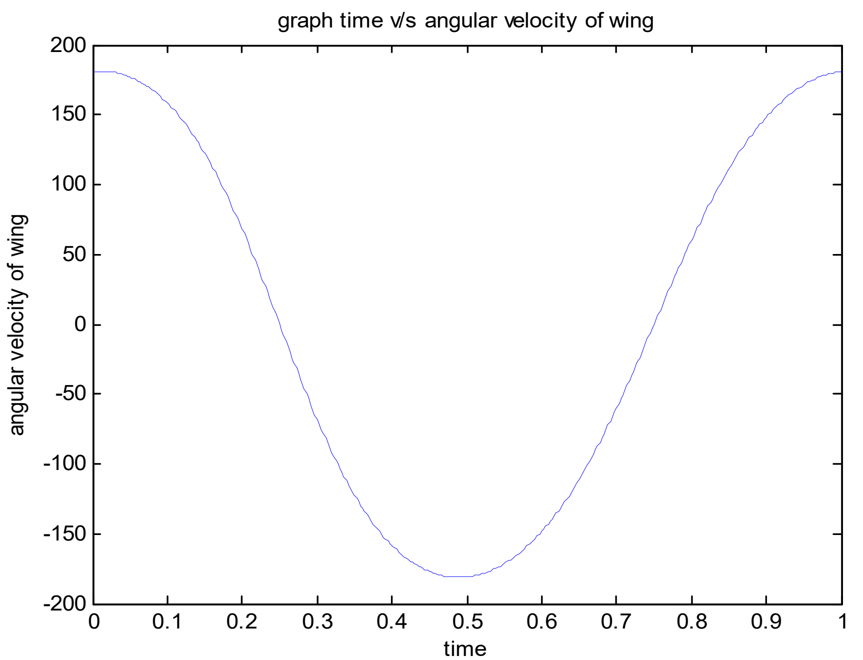

Figure: 6 Graph between time and angular velocity of wings

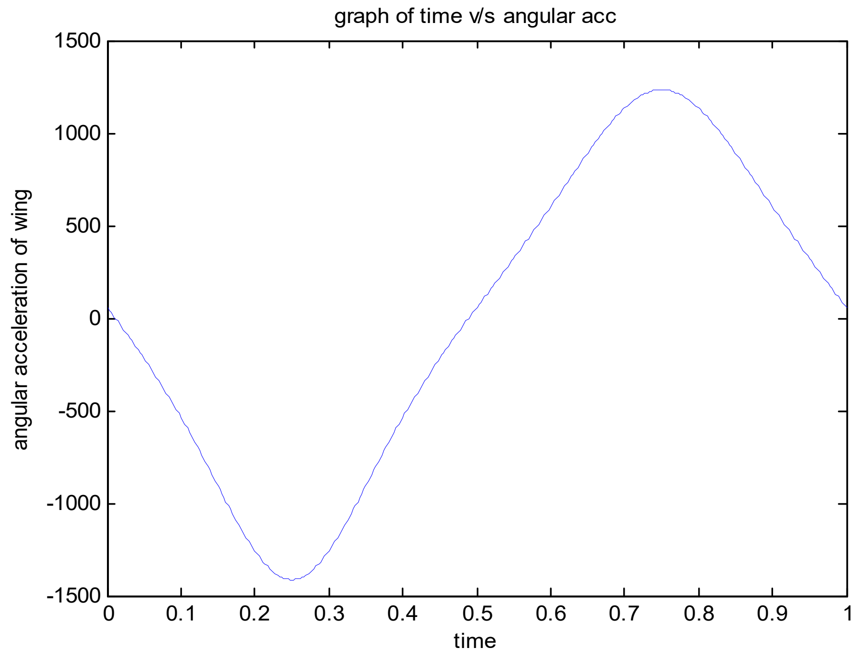

Figure: 7 Graph between time and angular acc.

6 CONCLUSION AND FUTURE SCOPE

In order to work with the dynamics and controls of a flapping wing flying vehicle while these future targets are currently in development a scaled up adaptation has been designed and built. With its bigger payload limit it's fit for conveying a completely prepared PC and top of the line inertial estimation unit with the choice of future increases of GPS or other more extraordinary sensors. Fuselage should be made up of carbon fibre plate which has more stiffness and strength as compared to acrylic sheet which is brittle. Add up to material examination on the best materials for the ornithopter in light of weight, basic soundness, harm opposition, and cost. This would be fundamental to locate the ideal material for the ornithopter. The weight on the material could be ascertained utilizing programming. Solar panel can also be used on the fuselage, tail and some other parts of the ornithopter so that energy efficiency can be increase.

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