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DESIGN AND FABRICATION OF ORNITHOPTER

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Abstract - *The ornithopter is a mechanically designed robot that uses a flapping wing mechanism to achieve flight. These designs are inspired by natural aviators such as birds and insects known for their ease of flight and maneuverability in the open sky. However, achieving this feat has presented a challenge due to the complexity of understanding its working dynamics. They autonomously vary the flapping rate and adjust the orientation of their tail to sustain steady flight in the atmosphere. Many experiments were conducted to develop the precise mechanism, to help thoroughly understand the dynamics of its machinery, and solving the enigma of its sustained flight in the air. The main objective of the project is to mimic the fluttering actions of a natural bird and understand its flight patterns. Recreating a sizeable model capable of manifesting the same functions as a bird but with other additional features such as surveillance, image capturing. These improvements have wide applications in the military field, research field, and general public applications. This model can be controlled over a long distance using a remote control. Hence, the altitude and the model speed can be controlled by the same. The interest rate on this subject has increased in developing ornithopter based on different aviators. Different methodologies were initiated to comprehend how to maintain long-range coverage, use of solar energy to recharge its power source and to sustain long-duration flight and working time.*

***Key Words*: natural aviators, manoeuvrability, fluttering action, surveillance.**

1. INTRODUCTION

Natural flyers have always been fascinating based on how they fly in the air. Researchers were intrigued by the thought of replicating such unique characteristics into an artificial model. These are categorized under the action of micro aerial vehicles (MAV). Includes design and fabrication of miniaturized model inspired by actual size natural flyers. Mini aerial vehicles have already been introduced, but they all function under the rotary type mechanism whereas the ornithopter uses a flapping (fluttering) mechanism to achieve flight. However, these miniaturized models have better maneuverability and are stealth comparing to other aerial vehicles that are capable of reaching its destination without getting detected by the radar. The main drawback of this prototype is the static lift off. Implementation of the spring leg system does not provide support to the model like wheels which help in achieving speed during lift-off. Complete flapping action for static lift, in turn, exerts excess pressure on other systems, thereby increasing the load on the model.

The working methodology involves gear ratio and the flapping rate of the wings. They differ during the lift and forward movement of the model. Where other conditions come into play during flight wind speed, rain, and other circumstances. These models have several complications; the autonomous flight control of the model is incipient. The problem caused may be due to non-linearity in their flight pattern. As the actuators for its working are less, the number of possible functions is not easy to ascertain…

2. LITERATURE REVIEW

"In recent years the topic of flying vehicles propelled by flapping wings, conjointly referred to as ornithopters have been a vicinity of interest thanks to its application to Micro Aerial Vehicles (MAVs). These miniature vehicles request to mimic little birds and insects to attain never before seen lightweight on the wing. This revived interest has raised a bunch of latest issues in vehicle dynamics and management to explore, (Zachary John Jackowski, 2009)" [1]. "Hovering is employing a horizontal wing path to lift; bees, wasps, and helicopters use this system. Dragonflies hover employing the distinctive technique, by flutter on Associate in Nursing inclined stroke plane. They look to form the next potency than is feasible for traditional hovering. This project aims to create a mechanical model to mimic the mechanical properties and hovering motion of dragonflies, (John H Lienhard V, 2007)" [2]. "Control physics is integrated with a microcontroller, mechanical phenomenon and visual sensors, communication physics, and motor drivers. It was needed to develop a simplified mechanical model of ornithopter flight to scale back the order of the system. The mechanics model and also the orientation estimation from aboard mechanical phenomenon sensors gift control of Associate in nursing ornithopter capable of flying toward target victimization aboard sensing and machine resources solely. To this finish, a dead-reckoning algorithmic program developed to pass through the temporary loss of the target that may occur with a visible detector with a slender field, (Stanley Seunghoon Baek, 2011)" [3]. Therefore, many aspects were taken into consideration during the research required for the model.

3. PROBLEM DEFINITION AND METHODOLOGY

The basic methodology used in this model is a flapping wing mechanism. They hold the key features required for flight of the prototype. Although it is seen to be impossible to achieve the exact moment of wing actions through mechanical behavior of a model certain aspects can be mimicked to insurance working.

Moreover, even when the shape of wings add on to their behavior in air. For example,the shape of a swallow wings are different from that of a pelican. Swallows are quick to cover short distance and sharp turns but pelicans can last longer, this is due to the wingspan. So selection of the wing shape is crucial pertaining to the type of application required for the model. The selection of material also has a huge effect in working of the prototype. Many factors should be added to generate the most precise type of materials used.

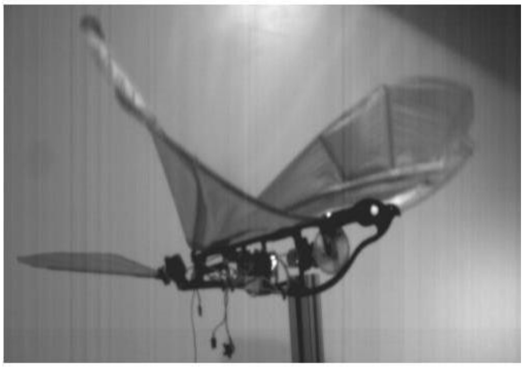

Fig.-3.1

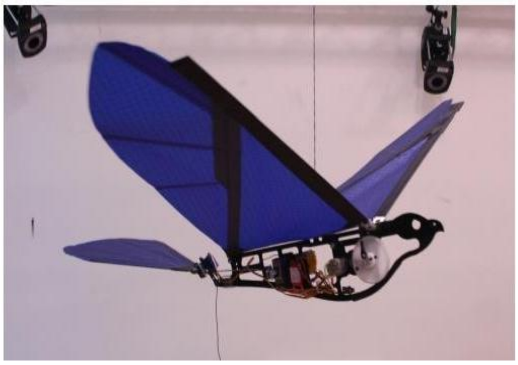

Fig-3.2

Fig-3.1 & 3.2: are the wing type used in the ornithopter

4. OPERATING PRINCIPLE OF WINGS

The general principle of wings called for the increase in pressure below the ring then on top of the wing in an aero plane. But in the flapping of birds the upper stroke is slower than the downward stroke to ensure its flight. During this downward stroke the pressure is more in the mid part of the wing and the outwards when compared to the part closer to the body. As the main focus of the pressure should be in the middle they are shaped point towards the end. However, most of the pressure acts at the middle part of the wing. This in turn helps the bird to exert the pressure required enough to lift them off the ground.

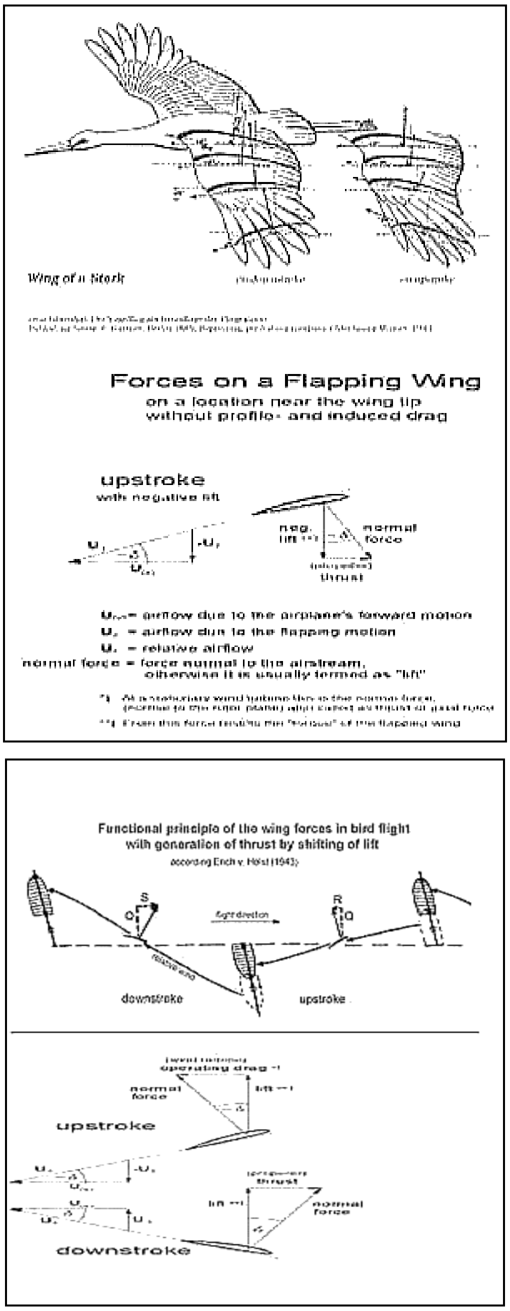

Fig-4: Wing flapping forces.

4.1. Distribution curve for flapping wings

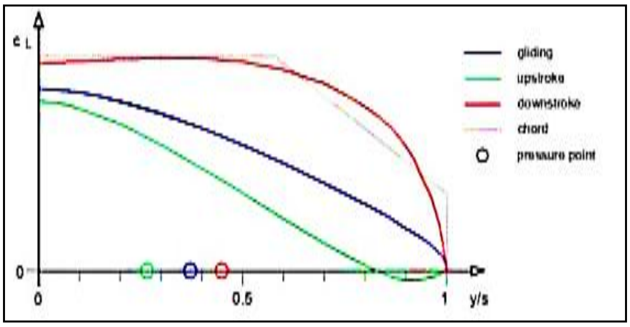

Fig-4.1: Force distribution.

These are lift distributions for flapping wings suitable for "flying with lift" in a gently inclined climb flight. In relation to the wingspan the affected a relative le small average torque around the pivot of the wing.

Compare to the electrical distribution here the lift distribution of the gliding flight is more tapered. In relation to the bending moment at the wing root and the induced drag it is optimal for unlimited wing span. At the time elliptical distribution with its 15% smaller wing span.

The lift distribution of the upstroke differs here not too far from the elliptical distribution. In the strokes, however, the size and the change of the induced drag place only a minor role. At least this shall be the case if the angle of incidence at the wing root during the planting flight is kept constant.

Advisably, the distribution of wing chord will be approximated to the left distribution shape of the downward stroke stop from the wing root to about the center of the wing half span the wing depth is almost constant. From there to the wing tip the outline is tapered. (For example like having of a duck, pigeon or seagull).

5. COMPONENTS USED

5.1. Body

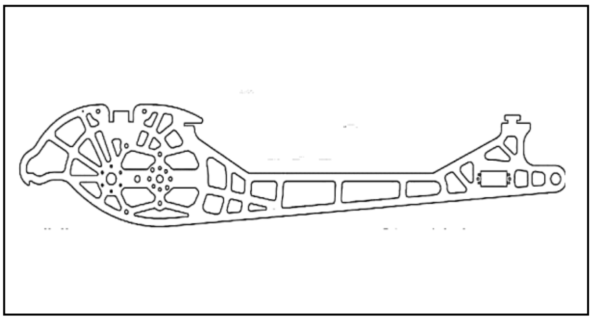

Fig-5.1: Mechanism body.

The body is made from a carbon fiber frame where the electronic components are attached. The slots are cut out based on the dimension of each components and predetermined locations. These Efficient slots are already cut help keep the electronic components fixed in place. The carbon frame is used as it is lightweight and has high durability in the presence of slightly strong wind.

5.2. Gear Mechanism

The gear mechanism was determined based on the number of teeth required on the gear. This was calculated based on the required flapping rate per second that is 5 up and down strokes per second to maintain flight. An external battery is connected to the gear mechanism as the power source. Furthermore, the flapping rate can increase or decrease based on the flight needs of the ornithopter.

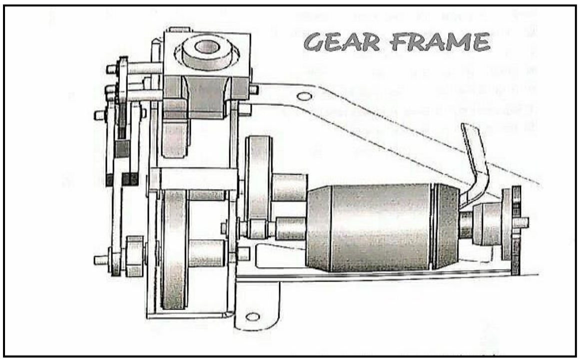

Fig-5.2: Gear mechanism

5.3. Wings

Fig-5.3(a): Teflon material.

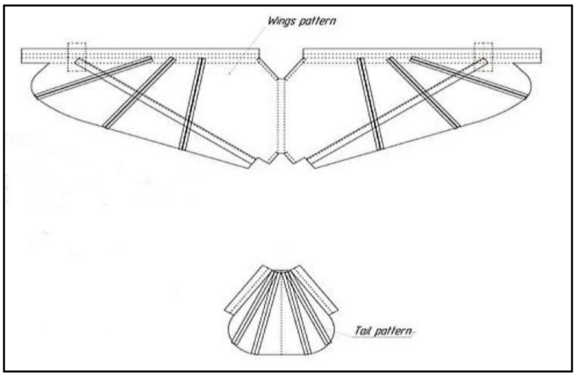

Fig-5.3(b): Wing patterns.

The material used for wink are carbon fiber rods and Teflon sheets. They have the durability as well as lightweight features. The carbon fiber rods are placed in crisscross manner and are stitched not the fabric. The exoskeleton of the wings are almost shaped like the exoskeleton of bat wings. This pattern provides much more flexibility in maintaining the pressure distribution throughout the wing.

6. CALCULATIONS

The calculations are based on the data acquired from the components used,

Dc motor – 3700 kV or 4200 kV

Battery – 7.4 V or 11.1 V

1) The speed of the model can be determined by the data obtained,

Speed = 3700 × 7.4
= 444 Rps.

Speed = 4200 × 11.1
= 777 Rps.

2) Gear teeth ratio of the gear mechanism is required to find out the flapping rate for the motor,
W.K.T n1 = 444 Rps. n2 =?
Using the formula,

$$\frac{n1}{n2} = \frac{z2}{z1} = \frac{d2}{d1} \qquad (1)$$

Using the gear teeth of 72, 8, 9 and 84.

444 / n2 = 84 / 9

n2 = 47.57 Rps.

Therefore,

47.57 = n2 / n3 = 72/8

n3 = 5.285 Rps.

Hence, the number of flaps are found to be 5.285 flaps per second.

3) For the battery used in mAh, it depends on the model, If the average current drawn is 15 A for 10 minutes, then

$$c = I \times t. \qquad (2)$$

15 × 10 / 60 = 2500 mAh.

4) For current rate 'C',
If peak current drawn is 30 A from 3000 mAh

C = 30 A / 3000 mAh

= 10 C.

7. ELECTRONIC CIRCUIT

Electronics makeup for the controlling and other part behavior of the prototype for the operator to control its movements. This comprises of all the electronic components into including the Arduino board, speed controller, servo motor, polymer batteries and other components.

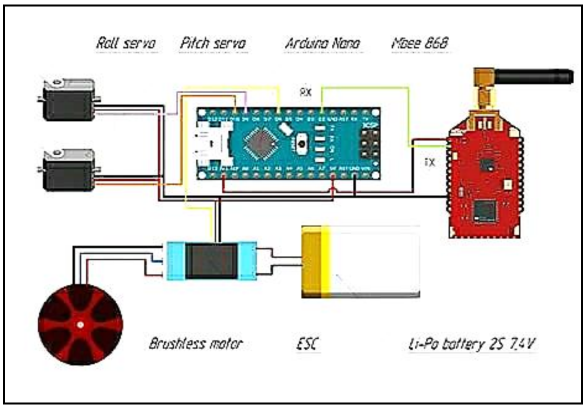

Fig-7.1: Circuit connections on the ornithopter.

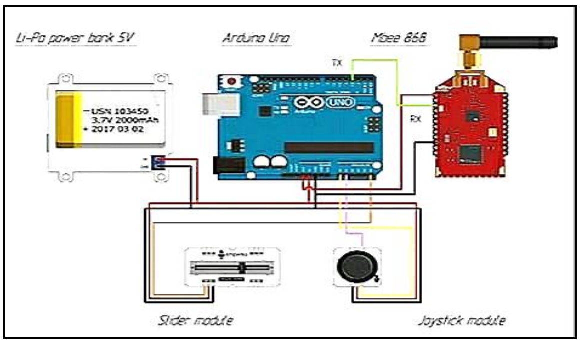

Fig-7.2: Circuit connections on the remote controller.

The motion of control takes place with the operator sending signals via the remote control to the model using RF signals already coded into the Arduino board. The speed and direction can be controlled by a speed controller and a servo motor.

The controller sends and receives radio frequency signals to operate the prototype. Long range can be maintained by using a distinct range of RF frequency already programed into the system to avoid unwanted interruptions.

8. CONCLUSION

The ornithopter is one of the most promising models which has infinite capabilities from surveillance to crop protection. Furthermore, many numbers of attachments can be added as a result of increasing the functional abilities of the ornithopter. The camera can be installed to capture images of the surveillance object or area. Sonar transmitters capable of producing ultrasonic waves can be used to determine the difference between obstacles and prototypes. And ultrasonic waves of much low frequency can be generated to scare away birds from field and runways in the airport. The use of a solar power battery enables the prototype to recharge during daylight and use the same energy has an efficient power source. And if surveillance is required during night time, this solar power cell can be utilized to produce power to the model. The use of solar batteries is much more efficient and eco-friendly.

Fig-8.1: Prototype.

Though many surveillance drones are already present in the daily market, they are perceptible and expensive. An ornithopter is a winged mechanical flying robot mimicking the actions and mechanism of a natural flier. It includes design and materials used for its fabrication, how they function, and the nature of its mechanism. These categorize under the Micro Ariel Vehicle (MAV) section, which mainly focuses on miniaturizing other sizeable models and use them for practical applications in different fields. Many experiments have been conducted on this topic to implement these natural mechanisms into an artificially created mechanical model that exhibits the functionality of the opted specimen. Due to a lack of information on the subject, it has been difficult in achieving the required results from the models. Even though the model can achieve flight, the autonomous flight controls of the model are incipient. This may be due to its autonomous nonlinearity in their flight pattern or their body movement concerning the wind direction

The following conclusions are drawn from the work:

1. Surveillance is carried out using the model, images are sent back taken by the lens attachment to the system.
2. Use of RF signal helps in the wide range operations.
3. Sonar detectors range the distance between the model and upcoming obstacles.
4. The model is capable of generating low frequency of ultra-sonic waves to scare away birds from fields and airport runways. This generated frequency is not harmful to birds.

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