



JOURNAL ON COMMUNICATIONS

ISSN:1000-436X

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DESIGN AND FABRICATION OF ORNITHOPTER

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1. Abstract:

In this essay, the theoretical idea of creating a powered ornithopter is presented. Taking into account concepts from various prior attempts to construct such a machine. The wings have been created in such a way that they roughly mimic the natural flapping of birds of the appropriate size and pattern. The mechanism described in this article is built on a number of bar linkages to replicate the precise flapping motion of a real bird. The concept is theoretically condensed before being computed and examined using tools for aerodynamics and other fields. Later development and prototype testing would confirm the validity of the given conclusions.

Keywords: Ornithopter, Aerodynamic Wings, Prototype

2. Introduction

People have always wanted to be able to fly like birds. Before the Wright Brothers' creation of flight, ornithopters had already been in development. Though the idea of flying like a bird could never be achieved in sustainable way, there have been notable progresses in the field so far. It has found that flapping flight has better propulsive efficiency than propeller based flight. The invention of hang gliders, and aircraft enabled us to soar in air which is great accomplishment in itself. But still, researchers are trying to understand and replicate the flapping flight of birds, which has seen little achievements. This mystery must be cleared up. The use of flapping wings for propulsion in powered or unpowered, manned or unmanned flight has been studied by a number of academic and non-academic organisations. Since humans are naturally not evolved with stronger limb muscles as birds are, it becomes unlikely for human to achieve similar performance without bridging the gap between the natural strength of the body and the equivalent strength of the limbs required to propel a wing. A system that is light enough and small enough to hang from a person's body would allow him to power the flapping motion of the wings, producing both lift and thrust.

3. Purpose

A bird can move forward by controlling the intricate, multiple degrees of freedom movement of its wing. The goal is to mimic a huge bird's flapping motion. Pitch, sweep, and dihedral movements of the wing in relation to the body are all included in flapping. According to earlier studies, typical flapping results in shock loading of the wing at the end of each stroke, which lowers the system's effective thrust. It is necessary to find a straightforward yet efficient technique to reduce this loading on the body and the wings. The goal of the project is to create a standalone framework with a power supply, flapping wings, and a control system that can be attached to a person, enabling the full human-machine system.

4. Project requirement

- Light weight design
- Low wing loading shock

- Flexible wing movement instead of torsional type
- High controlled lift at low velocity
- Minimum take off distance
- Sustained flight for much time
- Minimum inertia effect on the wing
- Deliver best possible performance using minimum power input

5.Design:

5.1. Wings:

Ornithopters have low forward speeds, so the flapping wing needs to have a high lift at low speeds and be able to generate enough forward thrust as well. According to research by Liu ET AL [1], wings with the cross section of an airfoil S1223 (fig. 3(a)) have a high lift capacity and share characteristics with birds like seagulls and mergansers. Angle of attack must be periodically changed during flapping motion (AoA). According to the airfoil S1223's characteristics, it has a high positive lift coefficient for a wide range of AoA. As a result, this was selected for the wing section.

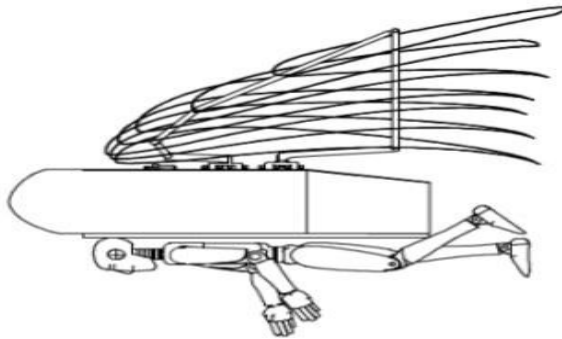


Fig :5.1(a). Side View of Created Design

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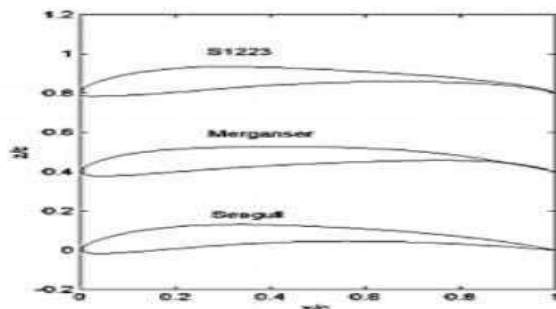
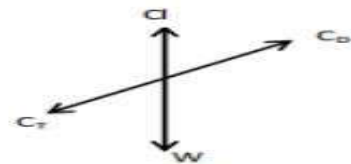


Fig:5.1(b) Graph



While drag decreases the efficiency of flight, it is essential for its stability.

Total drag over the wing is

given by, $D_{total} = D_{body} + D_{tail} + D_{wing} + D_{viscous} + D_{inviscid}$

As speed of flight is low the inviscid drag can be neglected. The effective total can be calculated and verified using computational tools. S1223 has very large lift to drag ratio for wide AoA and hence is suitable for low speed operation showing to its high camber

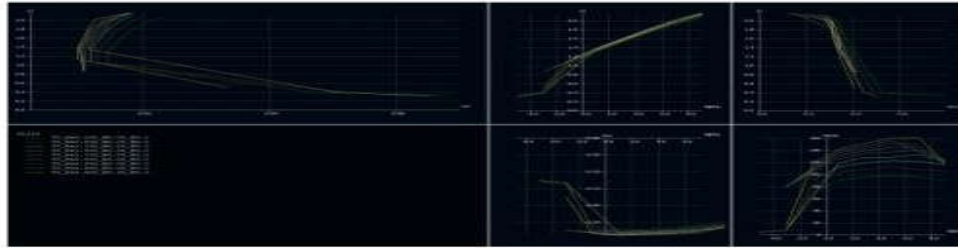


Fig:5.1(c). Performance curves

Additionally, this airfoil has a significant negative moment coefficient value. The system therefore has a propensity to have the nose point downward. It is necessary to determine a horizontal tail that would balance the system's pitching moment from a distance at the back. For this, a NACA 0012 symmetrical standard airfoil was used. It is thin an efficiently applied over wide variety of aircraft from gliders .

6. GEAR BOX

As a result, the needed torque to move each wing is equal to the product of the load times the distance ($1250 \text{ N} \times 1 \text{ m} = 1250 \text{ N m}$). By converting rotational motion to linear motion using an off-centered worm wheel, this amount of torque is to be supplied from the power source to each wing (fig. 7(b)). For the most effective torque-power curve, a conventional IC engine should rotate at a speed of at least 3600 rpm and typically about 5500 rpm. Reduction ratio necessary is equal to $3800/90 \text{ 43}$ when we use the available rpm range of 3800-5200. (chosen 3800 rpm) Either a single pair of worm-worm wheels or a combination of several spur gears can achieve this level of speed reduction. It is known that worm pair has very efficient performance where high reduction is required. Also, it provides a reverse lock feature. So we selected a worm pair of ratio 1:40 for our purpose. Next, reduction in speed means torque multiplication. Therefore, torque required

at output shaft of engine to drive the wing is given as follows:

Torque to wheel = $2 \times 1250 \text{ 0.051 0 165 Nm m}$

$$= 772 \text{ Nm. } T_{\text{Engine}} = 772/40 = 19 \text{ Nm } 3800\text{-}5200 \text{ maximum}$$

Gears for each pair of wing element are arranged in out-of-phase manner (fig. 8). This out of phase arrangement ensures that wing is always loaded and torque is continuously transferred from the engine shaft to wing. By this way, sudden wing loading at the end of each stroke is reduced.

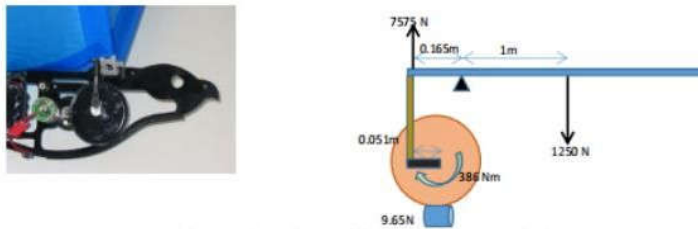


Fig:6.1.Kestrel Ornithopter

7. Frame

Frame is designed based on the weight criteria and the dimension of the internal drive system. From aerodynamic point of view, frame need to be as compact as possible so as to minimize the moment of inertia. Material used is to be alloy metal at critical load bearing areas while carbon composite at rest of the places.

8. Testing and Analysis Frame structure Analysis

Stress Analysis was performed over the frame keeping the frame base as fixed while upward load of 2500 N on the wing member and a high opposing torque moment of 4000Nm on the worm wheel. authors was little skeptic about applying Kestrel Ornithopter mechanism but these analysis predicted very good results . Stress is mostly concentrated at the worm wheel shaft which is obvious because of the torsional loading on it.

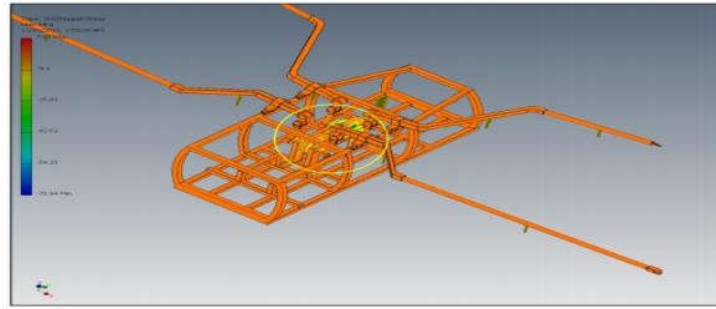


Fig:8.1.Static loading-Stress concentration

9.Aerodynamics Analysis

Since Angle of attack varies during flapping, we consider a range of angles during our analysis. Note that the pressure difference between upper and lower surface of wing near the root is maximum (about 210 Pa) which gradually decreases towards tip (about 44 Pa). Hence we are generating lift at $AoA = 0$ near the wing root. Also, notice there is a sudden surge in pressure at center near the body. This is because the body is not covered and is not aerodynamic during test.

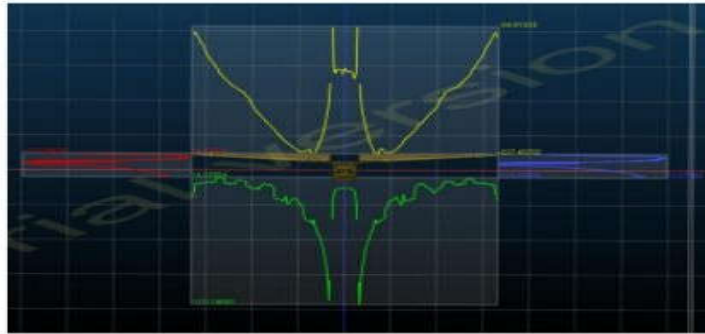


Fig.9.1. Static pressure variation



Fig 9.2.Fabrication Of Ornithopter Prototype

A flying machine with wings that flap is known as an ornithopter. The ornithopter operates similarly to an aeroplane in that forward motion through the air causes the wings to deflect air downward, creating lift. The design concept that is being discussed here, in my opinion, could use a lot of further improvement. We would be able to verify every component of the system with more work and perhaps prototype testing.

10. Conclusion

The model incorporates the concept of kinematic link joints. The idea needs extensive testing because it hasn't been used in an ornithopter in practise. Some of the analysis's findings are discovered to be consistent with norms and theories. At this point in the project, this is good. With an effort to adapt similar traits, the wing geometry is similar to that of a huge bird. The model is undergoing aerodynamic analysis, and the results thus far have provided us with a useful understanding of a potential flight. While the design of the flapping wing receives the majority of attention, designs are also being made for the horizontal tail, landing gear, and a thorough dynamic analysis of the wing. is being carried out. Also, current work is on the dynamics and control of the system.

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