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DESIGNANDFABRICATIONOFORNITHOPTER

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1.Abstract:

In this essay, the theoretical idea of creating a powered ornithopter is presented.Taking intoaccount concepts from various prior attempts to construct such a machine. The wings have beencreatedinsuchawaythattheyroughlymimicthenaturalflappingofbirdsoftheappropriatesizeand pattern. The mechanism described in this article is built on a number of bar linkages toreplicatethepreciseflappingmotionofarealbird.Theconceptistheoreticallycondensedbeforebeing computed and examined using tools for aerodynamics and other fields. Later developmentandprototypetesting would confirm thevalidityof thegiven conclusions.

Keywords:Ornithopter,AerodynamicWings,Prototype

2. Introduction

Peoplehavealwayswantedtobeabletoflylikebirds.BeforetheWright Brothers'creationof flight, ornithopters had already been in development. Though the idea of flying like a birdcouldneverbeachievedinsustainableway,therehavebeennotableprogressesinthefieldsofar.It has found that flapping flight has better propulsive efficiency than propeller based flight. Theinvention of hang gliders, and aircraft enabled us to soar in air which is great accomplishment initself. 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 wingsfor propulsion in powered or unpowered, manned or unmanned flight has been studied by anumber of academic and non-academic organisations. Since humans are naturally not evolvedwith stronger limb muscles as birds are, it becomes unlikely for human to achieve similarperformancewithoutbridgingthegapbetweenthenaturalstrengthofthebodyandtheequivalent strength of the limbs required to propel a wing. A system that is light enough and small enoughto hang from a person's body would allow him to power the flapping motion of the wings,producingbothlift and thrust.

3. Purpose

A bird can move forward by controlling the intricate, multiple degrees of freedom movement of itswing. The goal is to mimic a huge bird's flapping motion. Pitch, sweep, and dihedral movements of thewing in relation to the body are all included in flapping. According to earlier studies, typical flappingresults 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 thewings. The goal of the project is to create a standalone framework with a power supply, flapping wings,anda controlsystemthatcan be attachedto aperson,enablingthefullhuman-machinesystem.

4.Projectrequirement

- Lightweightdesign
- Lowwingloadingshock

- Flexiblewingmovement instead oftorsionaltype
- Highcontrolledlift atlowvelocity
- Minimumtakeoff distance
- Sustainedflightformuchtime
- Minimuminertiaeffect onthewing
- Deliverbestpossibleperformanceusingminimumpower input

5. Design:

5.1. Wings:

Ornithoptershavelowforwardspeeds,sotheflappingwingneedstohaveahighliftatlowspeedsandbeable to generate enough forward thrust as well. According to research by Liu ET AL [1], wings with thecross section of an airfoil S1223 (fig. 3(a)) have a high lift capacity and share characteristics with birdslikeseagullsandmergansers.Angleofattackmustbeperiodicallychangedduringflappingmotion(AoA).A ccording to the airfoil S1223's characteristics, it has a high positive lift coefficient for a wide range ofAoA.As a result,thiswasselectedfor the wingsection.

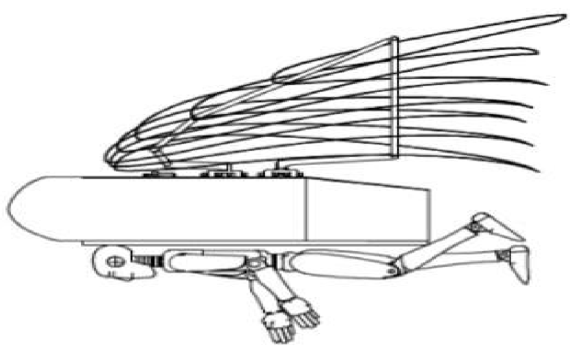

Fig:5.1(a).SideView ofCreatedDesign

Ornithopters have low forward speeds, hence the flapping wing needs to have a high lift at low speedsand be able to provide enough forward force as well. According to research by Liu ET AL [1], wingswith the cross section of an airfoil S1223 (fig. 3(a)) have a high lift capacity and share characteristicswith birds like seagulls and mergansers. Angle of attack must be periodically changed during flappingmotion (AoA). According to the airfoil S1223's characteristics, it has a high positive lift coefficient for awiderange ofAoA.This was therefore selectedforthewingsection.

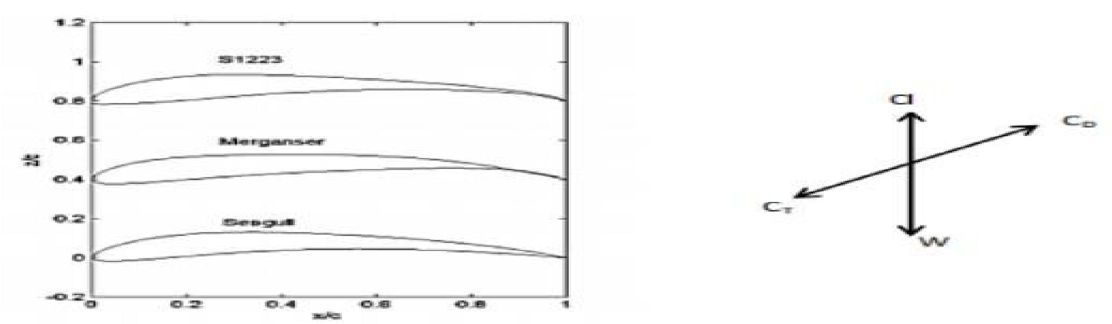

Fig:5.1(b)Graph

Whiledragdecreasestheefficiencyofflight,itisessentialforitsstability.

Totaldragover the wingis givenby,Dtotal = Dbody+Dtail +Dwing+Dviscous+Dinviscid

As speed of flight is low the inviscid drag can be neglected. The effective total can be calculated andverified using computational tools. S1223 has very large lift to drag ratio for wide AoA and hence issuitableforlowspeed operationshowingto itshigh camber

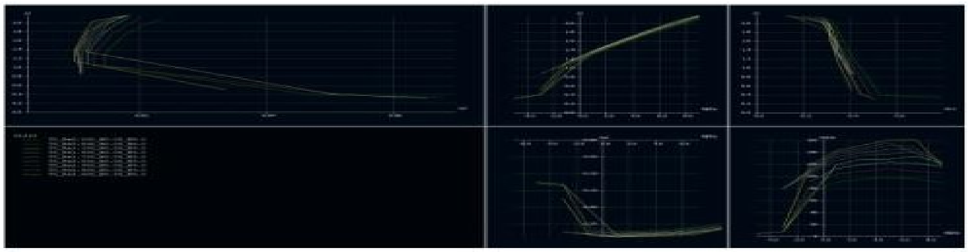

Fig:5.1(c).Performancecurves

Additionally, this airfoil has a significant negative moment coefficient value. The system therefore has apropensity to have the nose point downward. It is necessary to determine a horizontal tail that wouldbalance the system's pitching moment from a distance at the back. For this, a NACA 0012 symmetricalstandardairfoil was used.Itisthinanefficientlyappliedoverwidevarietyofaircraftfrom gliders.

6. GEARBOX

As a result, the needed torque to move each wing is equal to the product of the load times the distance(1250Nx1m=1250Nm).Byconvertingrotationalmotiontolinearmotionusinganoff-centeredwormwheel,thisamountoftorqueistobesuppliedfromthepowersourcetoeachwing(fig.7(b)).Forthe mosteffective torque-power curve, a conventional IC engine should rotate at a speed of at least 3600 rpm andtypicallyabout5500rpm.Reductionrationecessaryisequalto3800/9043whenweusetheavailablerpmrange of 3800-5200. (chosen 3800 rpm) Either a single pair of worm-worm wheels or a combination ofseveral spur gears can achieve this level of speed reduction. It is known that worm pair has very efficientperformance where high reduction is required. Also, it provides a reverse lock feature. So we selected awormpairofratio1:40forourpurpose.Next,reductioninspeedmeanstorquemultiplication.Therefore,torquer equired atoutput shaftofenginetodrivethewingisgivenasfollows:

Torqueto wheel= 2x12500.051 0 165 Nmm

=772Nm.T_{Engine}= 772/40 =19Nm3800-5200 maximum

Gears for each pair of wing element are arranged in out-of-phase manner (fig. 8). This out of phasearrangement ensures that wing is always loaded and torque is continuously transferred from the engineshaft to wing. Bythisway,sudden wingloadingattheend ofeachstroke inreduced.

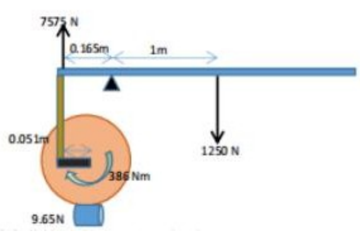

Fig:6.1.KestrelOrnithopter

7.Frame

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

8.TestingandAnalysisFramestructureAnalysis

StressAnalysiswasperformedovertheframekeepingtheframebaseasfixedwhileupwardloadof2500N on the wing member and a high opposing torque moment of 4000Nm on the worm wheel. authors waslittleskepticaboutapplyingKestrelOrnithoptermechanismbuttheseanalysispredictedverygoodresults.Stress is mostly concentrated at the worm wheel shaft which is obvious because of the torsional loadingon it.

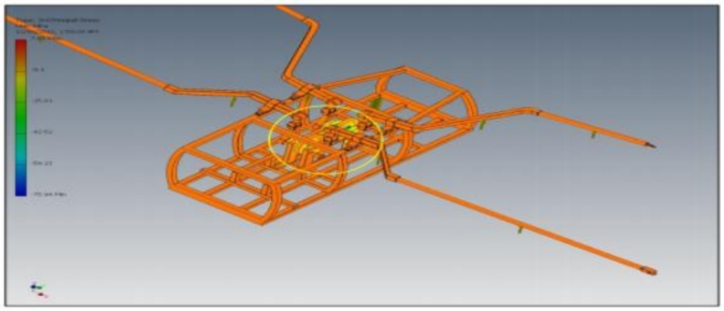

Fig:8.1.Staticloading-Stressconcentration

9.AerodynamicsAnalysis

Since Angle of attack varies during flapping, we consider a range of angles during our analysis Note thatthepressuredifferencebetweenupperandlowersurfaceofwingneartherootismaximum(about210Pa)which gradually decreases towards tip (about 44 Pa). Hence we are generating lift at AoA = 0 near thewing root. Also, notice there is a sudden surge in pressure at center near the body. This is because thebodyis notcoveredandisnotaerodynamic duringtest.

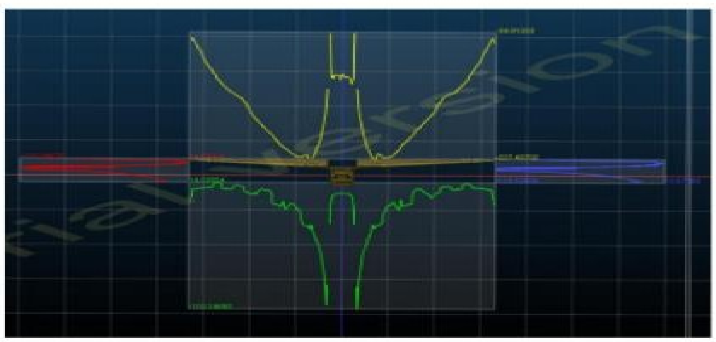

Fig.9.1.Staticpressurevariation

Fig9.2.FabricationOfOrnithopterPrototype

A flying machine with wings that flap is known as an ornithopter. The ornithopter operatessimilarlytoanaeroplaneinthatforwardmotionthroughtheaircausesthewingstodeflectairdownward,creating lift. The design concept that is being discussed here, in my opinion, could use a lot of furtherimprovement. We would be able to verify every component of the system with more work and perhapsprototypetesting.

10. Conclusion

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

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