Design and Development of Ornithopter

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Abstract

The early age of pioneers had concentrated their effort by observing the birds and had some marvelous engineering solution for human flight but, the technology was notessentially designed to mimic the flight of birds. In this paper we trying to designed a lightweight and high performance Ornithopter.This paper also describes the design and development of gearbox, wing frame and tail motion for ornithopter and review the effective electronic controlling techniques.

Keywords: -*ornithopter, maneuverability, mimics, surveillance***.**

I. INTRODUCTION

In today's growing aerospace industry and increasing applications there has been surge in new technology which can be utilized in high security surveillance applications, Wild life survey and Traffic Monitoring. Ornithopter has been under research from when we were trying to achieve manned flight. Over the years there has been quite a few developments but the technology wasn't adequate for the time. In this paper we reanalyzed the solutions from over the years and added many new developments to obtain a optimized design. The flapping wing design has many benefits, including improved efficiency, better maneuverability and reduced noise compared to traditional fixed wing and rotary aircrafts. Most ornithopters are created for hobbyist purposes, however, research into mimicking the biological systems of birds could lead to vast improvements in the aerospace market. Equipped with video cameras, transmitters, or sensors, these miniaturized aerial vehicles can perform surveillance, target sensing tasks at remote, hazardous, or dangerous locations.

II. Wing Design

A flapping wing design has been observed and optimized from that of birds. The total wing span consists of 45- 50 cm. The frame is designed such that it gives support to the wing and maintain structural integrity of the wing during the flight. Thefig below shows the frame of the wing structure. The frame is supported by carbon fiber rods and it is designed such that it gives aaero foil shape as well as strength to the structure.

Figure 1 :-Aerofoils

Figure 2:-Wing Frame Structure

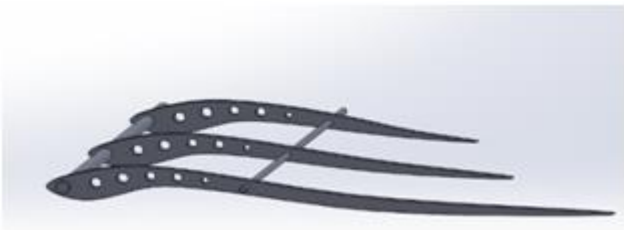

Figure 3:-CAD Model of Wing Frame Structure

The maximum load for which the ornithopter is designed is of 0.4 kg according to which thrust and lift calculations are done. The torque which is to be obtained at the is shoulder is calculated as 0.7848 Nm. The carbon fiber rods are carrying the maximum load which on the wing and the load is then transmitted to the shoulder. The wing material used is latex free rubber which has high elasticity and strength and better tear resistance than any other rubber material. The material thickness is 350 µm. The final wing frame is shown as above

III. GEARBOX

The most critical part of the ornithopter is the drive mechanism which converts the rotary motion of motor into the flapping motion of wing. The most important thing is need to be take in mind during the design of gearbox is it must be withstanding very large force and it also light and durable. Because of light in weight it must be made from Plastic. So, obtaining maximum flapping frequency of wing is 2 Hz, gear reduction for outer runner motor having specification speed of motor 7,200 RPM should be,

2 Hz = 2 x 60 = 120 rpm

7,200 / 120 = 60

The gear reduction should be 60. Which means while the motor rotates 60 times the main gear rotate once. This also reduces the torque needed for the motor. Less torque motor means a reduction in motor size and weight. For this reduction we select two stage gearbox.

GEAR NO.	PITCH DIAMETER	NO. OF TEETH	MODULE	QUANTITY
1	5	10	0.5	1
2	40	80	0.5	1
3	8	16	0.5	1
4	60	120	0.5	1

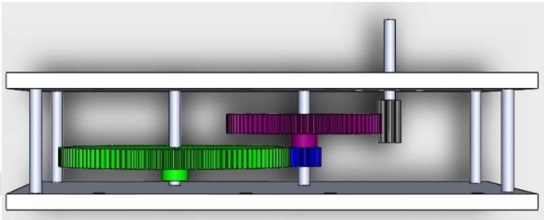

Figure 4:-Gearbox

The gear box design is done in SOLIDWORKS and these gears were assembled on two base plates for supporting them. The shafts used were 4mm mild steel shafts with push fit. For flapping motion of wing, we select simple four bar mechanism. Crank and wing shoulder(rocker) of mechanism must be strong for sustaining the large force and connecting rod should have some flexibility so for that tie rod is the best option.

IV. Electronics: -

Battery

While the electronics on the ornithopter aren't a critical system as far as the mechanical function of the machine performs, they do make up the one of the most important specifications for the project, the minimum payload capacity. Because the rest of the sizing and design of the ornithopter depends on this the weight of the computer, interface equipment, sensors, and battery must be determined first.

The battery used is a three-cell lithium polymer pack, the standard for high performance machines like airplanes on this scale because it has the best power and energy to weight ratios available. Power density is the main concern at the initial stages of the project because flights aren't expected to last for long which would make 19 power output the limiting factor for the battery. A lithium polymer battery can be discharged at up to 10 times its capacity (commonly referred to as 10C) with specially selected batteries capable of continuous discharge up to 30C which makes it able to deliver the short bursts of power that the ornithopter needs to flap during short test flights. It has a capacity of 350 mAh at 7.4 volts.

Camera

Along with the flight capabilities surveillance is also an important aspect so the camera used for surveillance is Eachine TX01 NTSC having a weight (Camera and Antenna) of 4.48 g and dimension as 34*20 mm. The antenna used is nickel plated 4 leaf mushrooms. The resolution of camera is 720*480p and it is operating at a voltage of 3.325 V. The transmitter has a frequency of 5.8GHz.

Figure 5:-Eachine TX01 NTSCFigure 6:-Flysky FS-i6x

Controller

Controller used for the ornithopter is Fly sky FS-i6x having configuration as frequency range in between 2.408 to 2.475 and 6 channel communication. It has a variety of controls which can be configured as per the user.

V. Tail: -

This tail assembly involves two servo motors namely SG90. These two are coupled together such as to get a 2 DOF motion. The first servo motor is connected to the rear side of the main body containing the flapping mechanism. Then the second servo is connected to the first servo by a flange which holds them together. The second servo is then joined at the end by the tail main body. The tail main body and the flanges joining the servos and the gear assembly are 3D printed using the PCA material. The tail body is comprised of the carbon fibre rods joined to the 3D printed part and the covered by the thin nylon sheet. This acts as the tail which moves in upward, downward and sideways as well.

The following design was established in order to gain the needed movements of the tail assembly. According to the following design assembly the first servo is directly connected to the main gear box assembly hence it would be stationary with respect to the whole ornithopter body. The shaft of this servo is connected to the next servo with a 3D printed flange. The first servo gives the motion in vertical direction. The second servo gives motion in the horizontal direction. In this way the two required movements are achieved

Conclusion: -

Figure 7:-Tail mechanism

The ornithopter was designed from the ground up with the needs of research in mind. All components have been designed to be as lightweight and high performance as possible so as to maximize payload capacity and are intended to fail in predicable and field repairable ways. Manual and initial autonomous flight tests have been conducted and show that the ornithopter is capable of sustained flight with a full load of electronics and can be stabilized by simple controllers in common use in aircraft. The complete design compromises of mixtures of new and existed ideas collaborated together to provide a cost effective and optimized solution.

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