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Design & Analysis of Ornithopter

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Abstract: *This project will present the design of a Flapping wing UAV which is inspired by various bird mechanisms and its action during flight. In this project, the real actions will be tried to convert into a perfect mechanism to get a stable flight maneuvering. The design will be made CATIA V5 with all the parameters according to the bird selected. And then the hexahedral mesh analysis had done and with the help of ANSYS- Fluent we had done CFD Analysis at a different angle of attack. To understand the working principle of ornithopters, various surveys were made on the natural flyers with flapping wings and their ability to produce lift and thrust. The crank mechanism is chosen to make the micro air vehicle (MAV) for spy work without being identified. This mechanism is one of the most complex ones, as its flow condition changes along with its wing motion. The mechanism is analyzed at two different speeds: 3 & 6 m/s. To analyze the aerodynamic characteristics, the lift and drag forces are measured at a different angle of attack using ANSYS software. The results are compared at various times with different working conditions to get the most suitable and reliable conditions. So, copying from the flying behavior of it is possible to gain all the abilities like the bird. And then after the analysis, we can able to analyze the lift & drag forces over the wings. They will consider factors such as wing geometry, wing flexibility, power source, control mechanisms, and structural integrity. The design process will involve the use of computer-aided design (CAD) software, allowing students to create detailed 3D models of their ornithopters. Once the design phase is complete, the project moves on to the analysis stage. It will employ computational fluid dynamics (CFD) simulations to evaluate the aerodynamic performance of their ornithopter designs. This analysis will enable them to optimize wing shape, wing kinematics, and other parameters to achieve efficient flight.*

Keywords*: Ornithopter, CAD Software, CFD Analysis, Wing Geometry.*

I. INTRODUCTION

An ornithopter is a flying machine or aircraft that achieves flight by imitating the flapping motion of bird wings. The word "ornithopter" is derived from the Greek words "ornithos," meaning bird, and "pteron," meaning wing. Unlike traditional fixed-wing aircraft that rely on the principle of lift generated by airflow over their wings, ornithopters generate lift by actively flapping their wings.

The concept of the ornithopter is inspired by the remarkable flight capabilities of birds, which have evolved over millions of years. By emulating the flapping motion and wing shape of birds, ornithopters aim to achieve more efficient and versatile flight. The flapping motion creates both lift and thrust, allowing ornithopters to manoeuvre through the air in a manner similar to birds. 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.

II. OBJECTIVES OF ORNITHOPTER

The objectives of designing and developing an ornithopter can vary depending on the specific project or application. However, some common objectives associated with ornithopter projects include:

1. **Biomimetic Flight:** Ornithopters aim to replicate the natural flight mechanisms of birds, with the objective of achieving flight that closely mimics avian capabilities. The primary goal is to study and understand the principles of flapping-wing flight and apply them to man-made flying machines.

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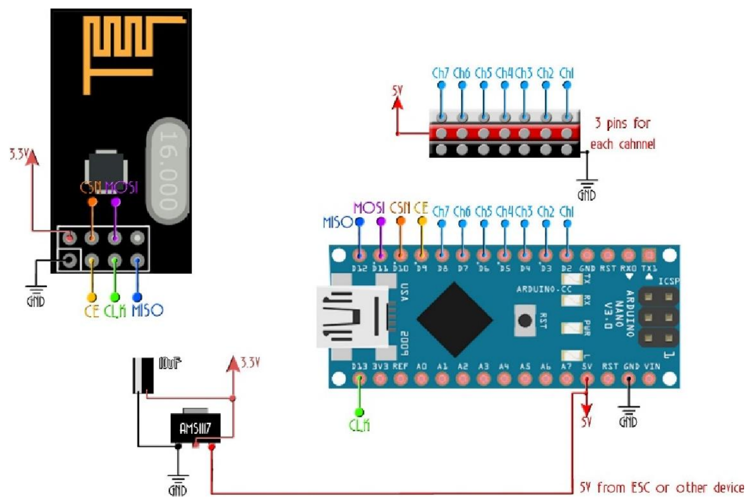
2. **Efficiency and Performance:** Ornithopter projects often focus on optimising the efficiency and performance of flapping-wing flight. This includes maximising lift and thrust generation, minimising energy consumption, improving manoeuvrability, and enhancing stability during flight. The objective is to develop ornithopters that can achieve sustained flight with improved aerodynamic characteristics.

3. **Design Innovation:** Ornithopter projects offer opportunities for design innovation and creativity. Engineers and researchers strive to develop novel designs for wing structures, wing kinematics, control systems, and power sources. The objective is to explore new concepts and solutions that can enhance the performance and functionality of ornithopters.

III. DEVELOPMENT

1) Receiving Unit



It consists of 7.4v Battery powering station providing 5v with ESC data pin. Here we are using nrf24lo1 Module as radio communication and main microcontroller arduino nano type 2 for processing and other controlling application
To provide stable 3.3v to NRF module we use ams117 3.3v regulator to reduce voltage to 3.3v but the connection is not stable to stabilise it we use a 10k uf capacitor and to establish communication with radio module and microcontroller we use SPI communication and to connect battery motor and sensor be use male pin header. This Receiver uses PWM Control signal to control and translate transmitted code.

2) Mechanism

It is a two joint wing flapping mechanism; it used simple crank and lever mechanism to operate. It is combination of simple and easy combination of other small mechanisms.

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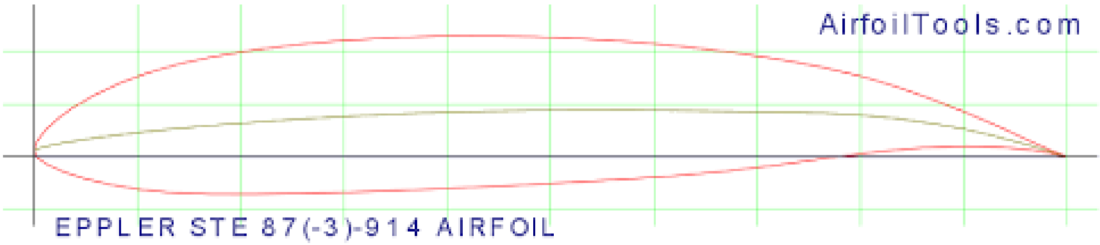
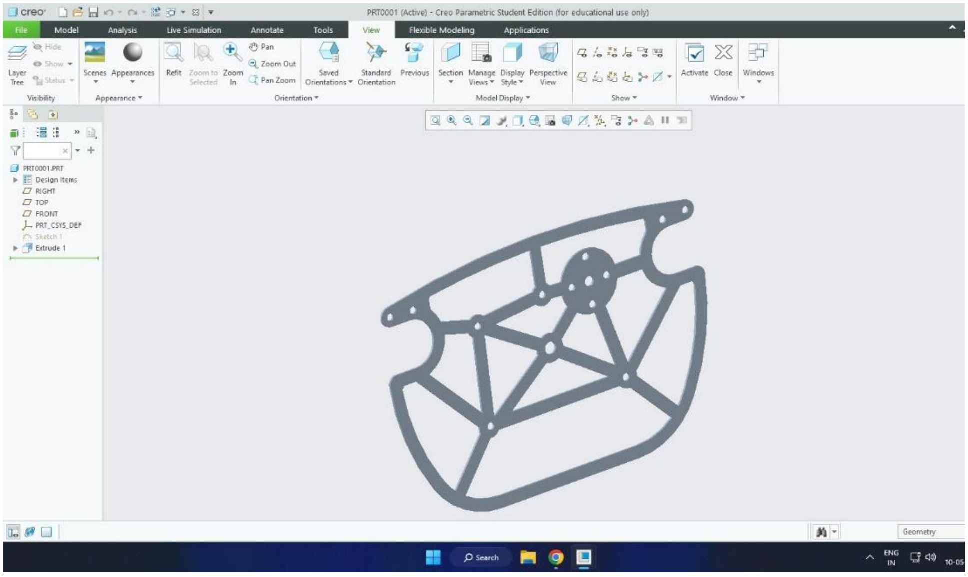
3) Airfoil Used

The selection of the Airfoil S1020-IL for ornithopter is based on several key factors that make it suitable for this specific application. Here are reasons for selecting this particular airfoil:

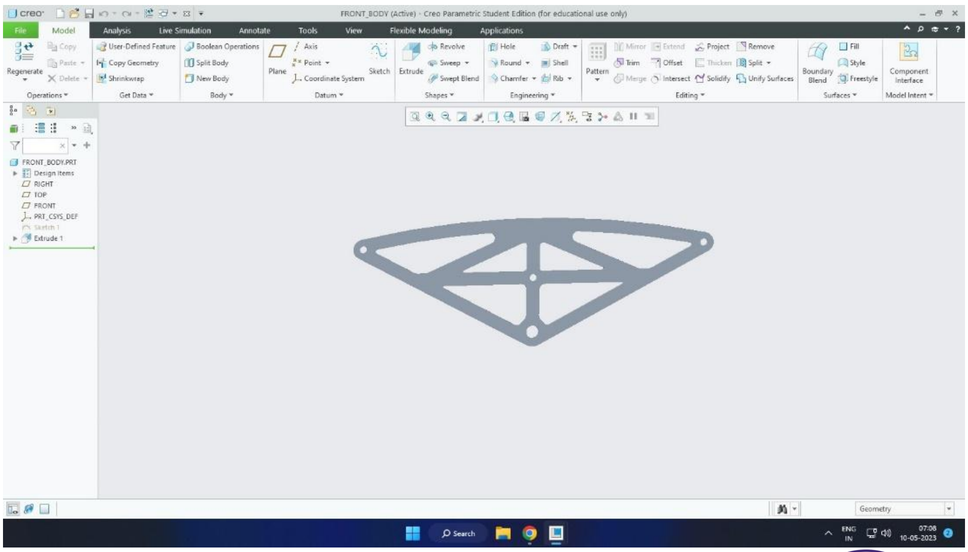


IV. SIMULATION RESULTS

1. Main Body:



2.Front Body Part:



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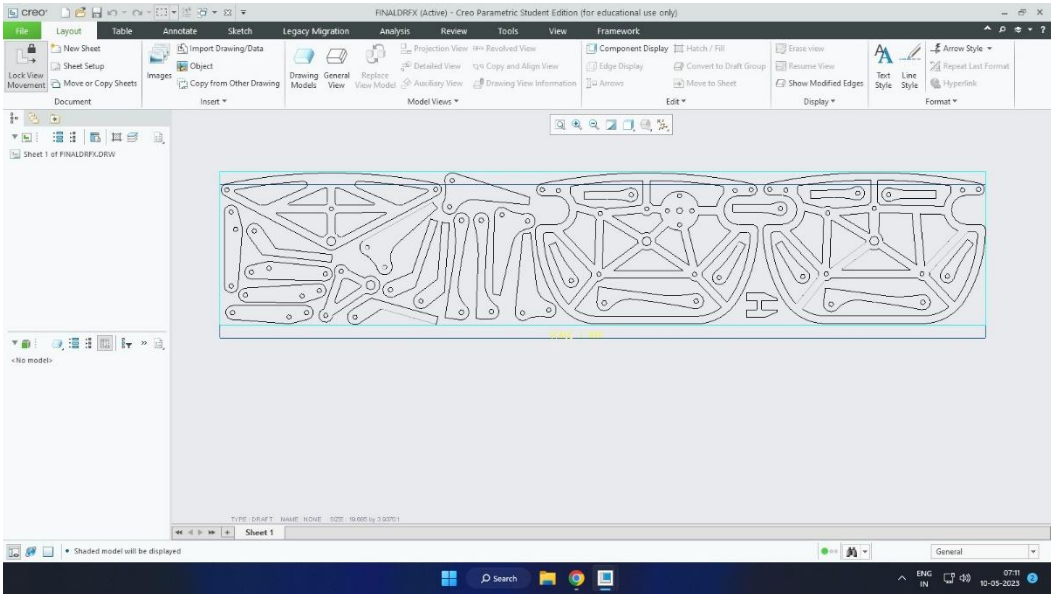
3.Other Linkages are drawn and assembled in one drawing for cutting in dfx format



V. CONCLUSION

The main aim of this project is to study the flying parameters of a bird and to design and analyze the structure of ornithopter. From this work, we will get the desired profile for the flapping wings and to compare the performance of it to the existing ones. This will give an idea to achieve the profile of the overall structure of the ornithopter that is efficient under optimum resources and energy consumption with minimal overall weight. So, to achieve this, we had decided the parameters for the structure of flapping wing UAV i.e., ornithopter for better efficiency in terms of resource. According to our project work, we calculated the lift and drag forces at two different angles of attack i.e., 6º & 12º both upward and downward (+ve& -ve) with two different flow velocity of air at 3m/s & 6m/s.

When the +ve angle of attack is given, then the bottom side of the wings is in direct contact with the flow which results in the high-pressure region on the bottom side and low-pressure region at the top side. And this will produce a force from the higher to lower pressure region area and help the bird to fly or takeoff and vice-versa with the –ve angle of attack. But when the velocity is increased the forces also increase of both lift as well as of drag with the increase in the angle of attack either in +ve or –ve the forces increase. Hence as per our project works, we can conclude that as long as the angle of attack increases until the critical angle of attack reached the lift and drag forces increases and the same results will come with the flow velocity. So, in our project the maximum lift force is with 6m/s flow velocity at flat 0º angle of attack and minimum drag is with 3m/s flow velocity at flat 0º angle of attack.

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