

Performance optimization on sailplane aerodynamics for better performance using sandwich panel method

Submitted in partial fulfillment of the requirements for the award of

Bachelor of engineering degree in Aeronautical Engineering

by

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DEPARTMENT OF AERONAUTICAL ENGINEERING

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade “A” by NAAC

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DEPARTMENT OF AERONAUTICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Venkata Subramanian (Reg. No. 38260039)** and **Rohit Rathore (Reg. No. 38260034)** who carried out the project entitled "**Performance optimization on sailplane aerodynamics for better performance using sandwich panel method**" under our supervision from September 2021 to April 2022.

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DECLARATION

I **ROHIT RATHORE** (Reg.No. 38260034) hereby declare that the Project Report entitled **Performance optimization on sailplane aerodynamics for better performance using sandwich panel method**” done by me under the guidance of **Dr. Manigandan, M.E., Ph.D.** at Sathyabama institute of science and technology submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Aeronautical Engineering.

DATE:

SIGNATURE OF THE CANDIDATE

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ABSTRACT

A sailplane is a type of glider aircraft used in the leisure activity and sport of gliding. Sailplanes are gliding models which are similar to airplanes with fixed wing configuration but with no propulsion. The aim of this research is to optimize the performance of the glider to give good results in its flying process. To achieve this expected result, we are using various methods and software to optimize the structural sandwich panel method and aerodynamics of the sailplane design.

Decreasing the interaction time in plan is one of the significant models for any field and henceforth robotization with assistance of CAD devices is extremely critical in decreasing time. This examination moreover targets building up a robotized model for various kinds of winglets and wing tip gadgets with the assistance of CAD innovation zeroed in on decreasing plan time during the underlying plan measure. Information based methodology is utilized in this work and all the models are defined so each model could be differed with related boundaries.

As a result, in addition to a precise airfoil design methodology, a precise method of analyzing the impact of winglet design elements on overall sailplane performance is necessary. The winglet's thin chords and low Reynolds numbers make meeting the requisite design goals more difficult. This scenario forces a trade-off between employing small to limit wetted area growth and using large to lessen wetted area rise. Once the fundamental chord dimension has been calculated, the spanwise chord distribution should be such that the stress on the winglet is virtually elliptical and the associated drag on the winglet itself is decreased.

Keywords: CATIA V5, Fuselage, Winglet, Induced drag, Knowledge Pattern, Parameterization

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LIST OF SYMBOLS AND ABBREVIATION

NASA	National Aeronautics and Space Administration
CATIA	Computer Aided Three-Dimensional Interactive Application
VB	Visual Basic KP- Knowledge Pattern
API	Aviation Partner Inc.
APB	Aviation Partners Boeing
CAE	Computer Aided Engineering
C_d	Profile drag coefficient
C_{di}	Induced drag coefficient
C_d	Total drag coefficients
F	Form factor
Q	Interference factor
S_{wet}	Wetted area of the surface
S_{ref}	Wing area
Re	Reynolds number of the component
V	Velocity
l	Component characteristics length
ν	Kinematic viscosity for that flight condition
e	Oswald's efficiency factor
AR	Aspect ratio
Cl	Lift coefficient
UDF	User Defined Feature

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CHAPTER NO: 1

INTRODUCTION

1.1INTRODUCTION

In this engineering design there is an amazing case study about the sailplane's abilities, with trials and errors, theoretical analysis has been performed so that it gives a solution for a difficult problem in the performance of the sailplane. In this paper this work resembles the importance of the sailplane glider with the effective Sandwich Panel method. In our Computational Aided Design (CAD) model we are using Skid type landing gear. Skid type landing gear help our model to land gently in the ground so that our model is protected in any type of surface where its lands. Our CAD model design in CATIA V5 software. Catia V5 is a software where provides a fully scalable platform for collaborative product creation and product data management. CATIA software is a complete multi-platform solution for CAD, manufacturing. 5 Fibre glass5, 3D. We are also using the STAR CCM+ software for analysis of our model. STAR CCM+ Software is type CFD analysis software, where we have done the analysis where our aerodynamic factors are involving like fluid flow, heat transfer, pressure, pressure coefficient, and related phenomena. This respective CAD Model has been 3D printed and been experimentally evaluated in sub-sonic wind tunnel in aerodynamic lab in our university.

One of the hardest aspects of the winglet design challenge is for calculating the sailplane glider performance. In existence, the winglet has various uses, or it spreads out and affects the tip vortex such that the downwash vortex and thus the drag has been reduced in this way or in this manner the winglet performs an end to the wing so that the vortex drag is reduced without any change in aerodynamic loading, and it can easily carry out this method in the to make or set right. So, in this we are clearly observing that reducing the profile drag can increase the speed of the sailplane and the high reduction of induced drag and small increase increment in the profile drag is the main objective of the designer.

The flight simulators which are not affordable for every people instead of that the radio controlled simply known as RC airplane are used for the real time flying with a small model and it can be afforded for every human being. Differences of angle of attack which is generate many ways magnitude of the drag and lift force without any change in their direction within the numerical model, this leads to a special weight of artificial sailplane glider designed model. A video camera was used to quantify the aerodynamic forces and flying performance of the radio-controlled sailplane model, which was then computationally, modelled using CFD software.

The design of the skid type landing gear is used in the aircraft for the best take-off and landing in a crucial or the emergency landings, so this landing gear is capable of landing in any type of landing ground without producing more stress impact in the sailplane fuselage cabin. Finally, data from sailplane glider and piston-engine flights are compared to show the deleterious impact of engine-induced vibrations on acceleration. The preliminary results of an ongoing parabolic flight test campaign carried out with an ASK-21 are presented Data was acquired used by made recorder, accelerometer, allowing us to pinpoint the exact level of zero-g obtained during parabolas as well as their time period. However, pilot feedback shows that a higher refresh rate would allow them to improve the parabolic trajectory and smooth their glider flying controls operations. The sailplanes are coming from the idea of bird soaring and using man has made a model and using that tried to fly that because of its aerodynamic design it flown in the air.

As a result, a design that can achieve the best lift-to-drag ratio while managing wing loads is necessary. The speed of the wind velocity has been changed using a knob and the results have been tabulated and the lift to drag ratio is calculated. When the drag and the pitch moment will change with respect to the chosen the varies test results and their results are compared with the test results of lift of the sailplane glider. The study also includes simulation and flight test results that demonstrate the proposed controller's effectiveness.

The searching of the flying tests also shows that using autonomous thermal soaring to extend the endurance of unmanned gliders is feasible and effective. This research is a continuation of the authors' project, in which a cooperative group of autonomous

soaring gliders has been positioned to improve the efficiency of thermal in the sailplane glider. As a result, when entering a thermal, it is critical to centre on the updraft as early as possible in order to achieve the maximum climb rate and make the most use of the time spent climbing. Turn rate restrictions and simplifications as a result, the cantering controller was flight-tested in an autonomous glider to ensure its performance. It is investigated how E' and E change while the glider climbs with a thermal to assess the controller's ability to centre the circular path above the updraft. The controller's goal is to change the UAV's flight path so that its centre coincides with that of the updraft by setting E' to zero, in which case E converges to a positive constant value over time.

The thermal cantering controller's properties were found to be reliably stable in both simulations and flight tests. Gliders and UAVs can fly in flapless flight into a strong wind to increase altitude and speed, just as albatrosses can. By comparing lift, lift-to-drag ratio, stalling characteristics, and pitching moment, flow around the wing was first researched to determine the best design of the sailplane wing. After utilizing an optimized wing configuration, the sailplane performance improved significantly, according to the experiment and calculations.

1.1.1WHAT IS SAILPLANE

A glider of such design that it is able to rise in an upward air current. A glider, often known as a sailplane, is a glider aircraft that is used for gliding as a recreational activity and sport (also called soaring). To gain altitude, this unpowered aircraft can take advantage of increasing air currents in the atmosphere. Because sailplanes are aerodynamically streamlined in the sailplane body, they can fly a long distance for a modest loss of altitude.

Carbon composites, fibreglass, aluminium, wood, special fabric stretched over steel tube, or any combination of these materials is used in the production of sailplanes.

Long, thin wings, a fully faired narrow cockpit, and a slim fuselage aid sailplanes by providing the least amount of drag for any given amount of lift. These characteristics enable aircraft to soar or climb quickly in rising air caused by thermals or hills. Sailplanes can glide great distances at high speeds with little loss of height in calm air. The wings of a sailplane are rigid, and the undercarriage is either skids or undercarriage. Hang gliders and paraglide, on the other hand, use the pilot's feet to commence the launch and land. These latter varieties are discussed in their own articles, while the contrasts between them and sailplanes are discussed here. Winch or aerotow are the most common means for launching sailplanes, while other methods, such as autopilot, are also used. Winch or aero tow are the most common means for launching sailplanes, while alternative methods such as auto tow and bungee are also employed on occasion. Almost all gliders nowadays are sailplanes, but many gliders were not in the past. These individuals did not soar.

They were basically engineless planes that were pulled to their destination by another plane and then cast off for landing. Military gliders were a classic example of non-soaring gliders (such as those used in the Second World War). They were frequently used only once before being abandoned after serving their purpose.

Gliders used to be mostly made of wood and metal, but now they're mostly made of composite materials like glass, carbon fiber, and aramid fibers. These kinds have a fuselage and long thin wings, i.e., a high aspect ratio, to reduce drag. There were enormous disparities in the appearance of early sailplanes in the beginning. As

technology and materials advanced, the need for the optimal mix of lift/drag, climbing ratio, and glide speed prompted engineers from many manufacturers around the world to construct similar designs. Gliders are available in single-seat and two-seat configurations.

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1.2 TYPES OF SAILPLANES

1. Hang glider.

A hang glider, like a sailplane, can be carried, launched, and landed entirely using the pilot's legs. The pilot is suspended from the middle of the flexible wing in the original and still most prevalent version, Class 1, and controls the aircraft by moving their weight.

Class 2 (FAI Sub-Class O-2) vehicles feature a rigid primary construction with moveable aerodynamic surfaces such as spoilers as the primary control technique. A fairing is frequently used to enclose the pilot. These are the most expensive and provide the best performance.

Class 4 hang gliders are unable to consistently exhibit the capacity to safely take-off and/or land in nil-wind conditions but are otherwise capable of being launched and landed.

Class 5 hang gliders feature a robust primary construction and use movable aerodynamic surfaces as the primary means of control, allowing them to take off and land safely in zero-wind situations. There are no pilot fairings allowed.

The shape of a hang gliders wing is defined by a structure, which distinguishes them from the other main type of foot-launched aircraft, paragliders, which are classified as Class 3. The term “powered hang glider” refers to hang gliders that have engines. Even though they may use the motor for the entire flight, they are normally classified as hang gliders by aviation authorities due to their commonality of parts, construction, and design. Ultra-light trikes, for example, feature a wheeled undercarriage and are hence not hang gliders.

2. Para gliders

A paraglide is a free-flying aircraft that is launched from the ground. The pilot is seated in a harness beneath a cloth wing. The shape of a paraglider wing is generated by the pressure of air entering vents or cells in the front of the wing, unlike that of a hang glider, which has frames. A ram-air wing is what this is called (similar to the smaller parachute design). The light and simple design of paragliders allows them to be packed and transported in big backpacks, making them one of the most easy and cost-effective ways of flight. Competition-level wings have glide ratios of up to 1:10 and can travel at speeds of up to 45 km/h (28 mph).

Paragliders, like sailplanes and hang gliders, gain altitude by using rising air (thermals or ridge lift). Most leisure flights and contests are based on this approach, however aerobatics and ‘spot landing competitions are also popular. Jogging down a slope is a common method of launch; however, winch launches behind a towing vehicle are also common. A powered paraglider, sometimes known as a paramotor, is a paraglider wing propelled by a motor mounted to the pilot’s back. The Para plane is a version of this, with a motor positioned on a wheeled chassis rather than the pilot’s back.

3. Military gliders

During World War II, military gliders were primarily employed to transport troops and heavy equipment to battle zones (see Glider infantry). Military transport planes, such as the C-47 Dakota, or bombers demoted to secondary missions, such as the Short Stirling, towed these planes into the air and most of the way to their target. They landed as close to the objective as possible after being released from the tug near the target. Heavy equipment could be landed, and the troops could be grouped rapidly

rather than being distributed throughout a drop zone, which gave them an advantage over paratroopers.

The gliders were viewed as disposable; therefore, they were built out of common and inexpensive materials like wood, though a few were rescued and re-used. Gliders had fallen out of favor by the time of the Korean War, as transport planes had grown larger and more efficient to the point that even light tanks could be dropped by parachute.

4. Research Sailplane

Gliders have been built for research even after the development of powered aircraft, where the lack of a powerplant reduces complexity and construction costs while speeding development, especially where new and poorly understood aerodynamic ideas are being tested that may require significant airframe changes. Delta wings, flying wings, lifting bodies, and other unusual lifting surfaces are examples of areas where previous theories were insufficiently developed to estimate full scale properties.

Horten flying wings, a scaled glider version of the Armstrong Whitworth A.W.52 jet propelled flying wing, are unpowered flying wings created for aerodynamic study.

5. Rocket Sailplane

Rocket-powered aircraft burn through their fuel quickly, therefore most must land without power unless another power source is available. The Lappish Ente was the first rocket plane, while the Messerschmitt Me 163 rocket-powered interceptor was one of the later variants. Starting with the Bell X-1 in 1946 and ending with the North American X-15, the American series of research aircraft spent more time flying unpowered than powered. Unpowered lifting bodies and the X-20 Dyna-Soar project was also studied in the 1960s, however despite the X20's cancellation, this research eventually led to the Space Shuttle.

6. Model glider

Model glider aircraft are scaled-down reproductions of full-size planes made out of lightweight materials including polystyrene, balsa wood, foam, and 11 fiberglass. The

designs range from simple gliders to highly detailed scale models, some of which are quite enormous. Larger outdoor variants are typically radio-controlled gliders that are piloted using a transmitter from the ground. Using the lift provided by slopes and thermals, they may stay airborne for long periods of time. A line linked to a hook under the fuselage with a ring can be used to winch these into the wind, with the line dropping when the model is overhead. Towing a model powered aircraft aloft, catapult-launching with an elastic bungee line, and hand-launching are all options for launching. The newer “discus” kind of wing-tip hand-launching has essentially replaced the earlier “javelin” type of launch when hand-launching.

1.3 SKID TYPE LANDING GEAR

A skid is a type of landing gear that consists of a series of beams that support the plane on the ground. Amphibious landing gear is designed to function on water using the airframe or floats attached to the airframe, as well as on land using wheeled landing gear. Tricycle, Tailwheel (Conventional), Pontoons, and Skis are the four fundamental types of landing gear used by General Aviation planes. Tricycle Gear planes are by far the most popular, as they are only slightly heavier than the earlier Tail-Wheel type but offer a few benefits. Landing gear is typically available in three-wheel configurations: standard, tandem, and tricycle. After that, landing gear is divided into two categories: fixed and retractable.

1.4 SANDWHICH PANEL METHOD

Sandwich panels are manufactured by attaching or laminating fibre reinforced skin plates to a lower-performance core such as structural foam, balsa wood, or honeycomb. The fiber configuration of the skins is usually quasi-isotropic. A sandwich panel is a type of construction cladding that is used to cover the walls and roofs. Each panel has a core that is wrapped in sheet metal on both sides. Sandwich panels are not intended to be used as structural components, but rather as decorative elements.

The bonded interfaces between the skin and the core are the most fatigue-prone areas in sandwich panels. There is a substantial risk of disbanding if the bonding is done manually (bond defects).

Damage to the skin-core interface or the weaker core is likely to develop with repetitive loading. A repetitive focused stress, such as a wheel load, may cause creep and degradation of the core cell structure, resulting in core property degradation.

A sandwich panel is made up of two rigid metal or composite faces and a porous low-density core, such as honeycomb or foam. Local crushing and global bending are the two most common processes used by sandwich panels to absorb impact energy.

The low-density core under the point of impact is crushed to a large extent in local crushing mode, and the flexibility of the cell walls absorbs a significant amount of energy. The entire structure bends and absorbs energy in a global bending mode due to elastic (or elastic/plastic in severe impacts) deformation of the structure. The sandwich panel's moment of inertia is unusually high due to the comparatively large distances between the faces, which also enhances its flexural stiffness. The flexural stiffness of this material is exceptionally high.

Because of the sandwich panel's high flexural stiffness and the core material's high flexibility, the sandwich structure has a high energy absorption capacity, making it ideal for high-energy impacts like bird strikes.

To prevent relative sliding of the sandwich faces during bending deformation, the core material must have higher shear strength. Furthermore, the core material must be stiff

to ensure flatness at its interfaces with the skins and to prevent wrinkling of the skins' undamaged portions during an impact process.

1.5 AIRFOIL SELECTION

This is significant for design because an airfoil with a camber that minimizes drag at the cruising CL can be chosen. The distribution of camber is taken into consideration for the regulation of pitching moment. In our project we have taken the fx74 cl140 mod airfoil because of its downward design on its end of the airfoil. So that the pitch moment is been increased.

1.6 ROLE OF GLIDING RESEARCH

Gliding research accounts for a tiny but important portion of aviation research. It makes a substantial contribution to aviation growth in many ways since, from its inception at the turn of the twentieth century, it has continued to serve science, society, and industry.

- 1.** As a source of new ideas,
- 2.** As a platform for experimentation in a variety of disciplines of technology, as well as fundamental and applied aerodynamic research, and
- 3.** As a source of highly motivated young researchers and industrial engineers for the entire aeronautical community

To begin, I'd want to provide some examples in order to back up these claims. Looking over the program of this OSTIV Congress and the several fields that will be addressed during the coming days will give you a good idea of the impact of gliding research.

Almost all of the accomplishments and plans discussed will eventually find their way into aviation, in some form or another. We prefer to concentrate on the more remarkable subjects, which I will discuss later, but it is vital to remember that the entire picture is made up of many small pieces.

Technology transfer does not necessarily happen right away; in many cases, it happens over time. Individuals who worked on the solutions share their knowledge

with friends and coworkers, and turn it into an asset of their organizations, where it is used directly or modified for similar applications

The investigations towards a safer glider winch launch or new air data sensors presented at this Congress will affect aviation in the end. Will it be the procedures, sensors, developed software, or the full system that we will discover in future aircraft and air traffic systems? Because technology has become little complicated, even seems some of the minor accomplishments and changes can have a significant impact.

CHAPTER NO:2

LITERATURE SURVEY: -

1. Research on sailplane aerodynamics at Delft University of Technology. Recent and present developments, Louis Bowerman's January 2006.

The objective of the boundary layer suction is to reduce drag by keeping the boundary layer laminar and attached up to trailing edge. This paper describes results of ongoing research on boundary layer control by suction, a beckoning perspective for significant drag reduction. The air is sucked through the porous outer skin, flows forward through perforated folded core and finally through throttling holes into the wing. The boundary Layer suction is used in the sailplane wing so when the sailplane is flying the air gets sucked into the wing through tiny pores on the wing and the air molecules will be surrounding inside the wing. These air molecules are being again sucked through the tiny tube and connected to an air pump and the air pump is pumping the air and then let out the molecules through the outlet duct.

This process is happening frequently so that this can produce some amount of lift to the sailplane. The speed polar of a high-performance sailplane, broken into contributions to the sink rate of the wing, fuselage, and tailplanes, shows that the wing contributes the most, with induced drag at low speeds and profile drag at high speeds. As a result, improvements have been concentrated on these factors, followed by the fuselage and tailplane drag, which is particularly noticeable at high speeds. Examples of innovative sailplane designs will be used to demonstrate these advances.

However, it should be noted that each new sailplane design incorporates enhancements similar to those discussed below for the individual sailplanes. The suction sandwich has many tiny holes in the upper skin, larger and fewer holes in the folded core, and even larger and fewer holes in the lower skin, similar to corrugated cardboard. The folded core is a new core material developed by the TU Stuttgart's Institute für Flugzeugbau. When pollen and debris are drawn into the suction sandwich, the channel type structure allows for cleaning of the interior structure.

2. Investigation of Dynamic Stall of Air foils and Wings by CFD Ercan Dumlupinar, V. Murthy 27 - 30 June 2011.

The objective of the Reduction in fabrication cost is becoming important as well. The focus of this research is to evaluate the effect of mean angle of attack on the pitching infinite and finite wings. The test cases considered for the calculation correspond to wind tunnel conditions of an experiment of a NACA 0015 pitching airfoil and a finite.

The objective of this work is to use a RANS solver to investigate the phenomena of dynamic stall for aerofoil and three-dimensional wings at operating conditions. One and two equations turbulence models are investigated for the RANS closure for two-dimensional cases. Based on these results, NACA0015 profile and all results compare well with the experimental measurements. Cobalt is a parallel, implicit, unstructured CFD code that solves the compressible Euler and Navier-Stokes equations. Five fundamental tasks comprise the flow solution algorithm for Cobalt Construction of initial condition for the Riemann problem at any given face.

For finite wing, the meshing of tip region using quadrilateral face elements caused problems to represent the wing tip. Therefore, the solver can handle the arbitrary cells a hybrid grid methodology is implemented in this study. Hybrid mesh is a combination of structured and unstructured grids. In many aerodynamic systems, dynamic stall is a complex unstable flow condition that has negative effects. In forward flight, the most typical incidence of dynamic stall is on the retreating blade of a rotor blade. When a lifting surface is quickly pitched beyond its static stall angle, this happens.

At the commencement of dynamic stall, the lift increases at first, then begins to decline in a highly nonlinear manner. The stall of the retreating blade is the fundamental limiting factor for a helicopter's maximum speed in level flight. The retreating blade may stall flutter, the helicopter may experience severe vibrations, or the rotor control system may encounter severe loads at speeds higher than the maximum permissible speeds.

For stall flutter, vibration response, aeroacoustics, and control system load in helicopters, dynamic stall prediction with associated pre and post aerodynamic loads is crucial. Because traditional inviscid studies do not match the needs, an accurate dynamic stall model that is computationally possible is required to effectively forecast

these occurrences. As a result, the goal of this project is to create RANS solver approaches for investigating dynamic stall phenomena and to validate the procedures by comparing the results to available experimental data.

3. Control Law Design for Improving UAV Performance Using Wind Turbulence. Chinmay K. Patel and Ilan Kroo 9 - 12 January 2006.

This paper deals with the design of simple control laws to extract energy from atmospheric turbulence. A point mass model is used to simulate glider lights through realistic gusts based on the Dryden power spectral density function, and an optimization procedure to design control laws under a random environment is presented. The results show that, for small UAVs, significant energy savings are possible using active control laws. Factors affecting energy extraction are outlined and issues arising in gust modelling, stochastic optimization, and realistic constraints are addressed. This work presents an interesting avenue in aircraft and control law design, stochastic optimization algorithms and aspects of bird light. Further work is required in the yield of gust sensing for UAVs and development of ancient optimization algorithms for the problem analysed here. This paper presents a simple analysis to illustrate the fundamental aspects of energy extraction from atmospheric turbulence. In this paper, the analysis is presented in dimensional form in order to facilitate the understanding of the concept. To compare several different aircraft, it would be necessary to use dimensionless parameters.

4. Design, Fabrication, and Initial Results of a 2g Autonomous Glider. J. Wood¹, S. Avadhanula¹, E. Steltz¹, M. Seeman¹, J. Entwistle¹, A. Bachrach¹, G. Barrows², S. Sanders¹, and R. S. Fearing^{1,3}

In essence, the aircraft performance has been improved so the winglets result from their ability to reduce induced drag traded off against their added wetted area increasing the profile drag. Within the use of core technologies of emerging micro robotic structures, the rapid design and prototyping of passive micro air vehicle with the final goal of locating an audio source while avoiding hazardous obstacles is presented. The airfoil and control surfaces are optimized empirically to maximize lift and manoeuvrability while the drag has been minimized. On many classes of micro air

vehicles, there is a huge body of existing and emerging study (MAVs). Such gadgets are loosely characterised as being on a scale of about 15cm in length and weighing less than 100g. MAVs can be used for a variety of tasks, including reconnaissance, hazardous environment investigation, and search and rescue. Molded short-fibre composite clips are used to connect the five subsystems: control surfaces and fuselage, airfoil, control PCB, imager PCB, and battery. This allows each item to stay modular and change its position in relation to the CG.

The glider is then linked to a low friction model aircraft balance and the position of each piece is picked to place the CG in the desired position (in relation to the roll and pitch axes). The effect of changing the CG can be seen in a flight simulator, although it is widely agreed that for best stability and manoeuvrability, it should be somewhat forward and slightly below the centre of lift.

5. Minimum shear wind strength required for dynamic soaring of albatrosses, GOTTFRIED SACHS 2005

One critical problem to solve was the removal of hat stiffener mandrel tooling from the cured part. Thus, the minimum shear wind strength required for dynamic soaring is determined. The aircraft has been used for soaring and it has been tracked using the mathematical optimization method is used for computing minimum shear wind energy-neutral trajectories, using a realistic flight mechanics model for the soaring purpose. This result holds for two control cases dealt with, one of which shows a freely selectable and the other a constant lift coefficient characteristic.

The mechanism of energy transfer from the shear flow to the bird is considered, and it is shown that there is a significant energy gain in the upper curve and a loss in the lower curve. As a result, the upper curve can be qualified as the characteristic flight phase of dynamic soaring to achieve an energy gain.

Another important result for dynamic soaring that concerns the drag effecting the energy balance during a dynamic soaring cycle the energy loss due to drag, which is the only source of energy loss for gliding in calm air, plays a minor role in dynamic soaring. It is significantly smaller than the energy transferred from the moving air to the bird and vice versa. This holds for the energy gain in the upper curve as well as for

the energy loss in the lower curve. As a result, the energy balance of dynamic soaring has been dominated by the energy exchange between the aircraft and the moving air.

6.A multibody approach for 6-DOF flight dynamics and stability analysis of the hawkmoth *Manduca sexta*, Joong-Kwan Kim and Jae-Hung Han Received 8 July 2013, revised 18 December 2013 Accepted for publication 20 December 2013 Published 22 January 2014

One way to avoid this problem is simply to prescribe the location of the surface and wake elements in a fashion that prevents any close encounters. This paper investigates the six degrees of freedom (6-DOF) flight dynamics and stability of the hawk moth *Manduca sexta* using a multibody dynamics approach that encompasses the effects of the time varying inertia tensor of all the body segments including two wings. The quasi-steady translational and unsteady rotational aerodynamics of the flapping wings is modelled with the blade element theory with aerodynamic coefficients derived from relevant experimental studies. The aerodynamics is applied at each of the integration time step without wingbeat-cycle-averaging.

With the multibody dynamic model and the aerodynamic model for the hawkmoth, a direct time integration of the fully coupled 6-DOF nonlinear multibody dynamics equations of motion is performed. The passive damping magnitude of each single DOF is quantitatively examined with the measure of the time taken to half of the initial velocity (*thalf*).

The results show that the sideslip translation is less damped approximately three times than the other two translational DOFs, and the pitch rotation is less damped approximately five times than the other two rotational DOFs.

The study accomplished the following: the inherent passive damping in each DOF was quantitatively examined and all the independent DOFs were found to be passively stable; while possessing passive stability, the pitch rotation and the sideslip translation were found to be least damped DOFs; the natural modes of motion of the hawkmoth multibody model were investigated by analysing the fully coupled 6-DOF dynamic responses to the force and moment disturbance initial conditions; and (4) the longitudinal instability due to the coupled dynamics, and the lateral instability due to

the coupled dynamics have been found to be the major unstable modes of the hawkmoth flight.

7. Technology Development in Sailplane Design. Neal J. Pfeiffer (2017) 01 2007

This paper cannot cover all the material on this topic. It will provide a mix of relevant Historical and technical information, beginning with an historical description of key gliders /sailplanes (primarily used for short gliding flights / or longer soaring flights).

This study will focus on structural and control-system elements, as well as how they evolved and allowed sailplane performance to improve. While there is some discussion of aerodynamics, it will be addressed in less depth than in the Maughmer paper. Because many of the items described here are historical reports, rather than attempting to identify specific sources for each one, a list of main historical resources that have been used for this work is provided below. These references frequently describe the same events and subjects, but with slightly different emphasis. The information in this paper is derived from a variety of sources.

The historical section will introduce a number of technical concepts, and then be followed by a section that discusses a number of specific design details. Oil visualization is problematic because the porous wing absorbs fluorescent oil, as demonstrated by the dramatic effect of oil spills on bird feathers. Sailplanes have been important in the development of aircraft. This paper will review the history of unpowered flight from early gliders to the modern sailplanes. Key gliders/sailplanes have been selected to represent various advancements in technology that have been applied to make aircraft more efficient and safer.

The discussion will include developments in aerodynamics, materials, structural layout, and control systems. It will also discuss the interaction of these items. Biplane gliders had changed into sailplanes with streamlined fuselages and cantilevered wings. Cross-country soaring using thermals were regularly achieved. Glide ratios reached 30:1 and the variometer had been invented. In aircraft the variometer is used as a rate of climb and descent indicator (RCDI), rate-of-climb indicator, vertical speed indicator (VSI), or vertical velocity indicator (VVI) is one of the flight instruments in an

aircraft used to inform the pilot of the rate of descent or climb. This variometer allowed the pilot to more easily locate and centre thermals. Reaching a 30:1 glide ratio allowed more time to find a thermal, and greatly increased the probability of staying aloft. Considerable progress was made in powered aircraft design during World War II. The NACA laminar flow Air foils sections found until sailplanes transitioned from wood to metal or composite, the full benefits of laminar flow were not realized.

The use of fibre-reinforced sandwich structure revolutionized the manufacture and performance of sailplanes. It became possible to obtain laminar flow with low weight and acceptable cost. Arafiles have been invaluable to the development of new ideas. Sandwich structures can be classed as composite materials in that they consist of two or more individual components of differing properties which when combined result in a high-performance material.

The first three gliders had a shoulder-mounted wing, with the first having a control stick for Wolf Hirth dangling from the leading edge of the wing ahead of the pilot. From 1936 through 1938, a number of adjustments were made to the production variants of the type after those original three. The wing was moved from the shoulder to the mid-fuselage position, the tail was changed from a full-flying surface to one with a fixed stabiliser and moving elevator, and airbrakes were added, either simply hinged DFS style or the Schempp-Hirth boards intended. In 1939, a final single glider with major aerodynamic improvements was created. Over 100 Minimoa gliders were built at the Schempp-Hirth factory.

8.Numerical study on the aerodynamic characteristics of both static and flapping wing with attachments Lingwang Xie, Xingwei Zhang *, Pan Luo, Panpan Huang2007

The purpose of this article is to look at the aerodynamic mechanism of airfoils under various icing scenarios, such as icing type, icing time, and icing position. For both static and flapping Airfoils, numerical simulation is carried out using the finite volume method. The current simulations show that several attachment influences are similar in the static and flapping Airfoils. The airfoil with the attachment generated from glaze ice type has inferior aerodynamic performance than the airfoil with the attachment developed from rime ice type. The usage of wind energy has progressed dramatically in recent decades. However, various issues should be addressed further in order to fully utilise wind energy. When wind turbines are utilised in high latitude areas, for example, the blades of the turbines frequently freeze due to the cold weather.

The attachment has a bigger impact on aerodynamic performance the longer the icing time is. The leading-edge attachments have a bigger impact on aerodynamic performance than other positions.

The ever demo criticizing excess to space easier access to microgravity and it will take more space systems are being developed and require testing and the cost estimation scales up for the microgravity environment. The static airfoil and the flapping airfoil have very little in common. The flapping airfoil with the attachment on the trailing edge has a worse aerodynamic performance than the static airfoil. The aerodynamic performance of asymmetrical Airfoils will be harmed by attachments produced from rime ice type and glaze ice type. The current paper presents a systematic and complete investigation of icing blades, which is beneficial to the advancement of wind power generation technology. The effects of the attachment on the surface of the airfoil on aerodynamic characteristics are carefully examined in this work. Following are some conclusions that can be drawn in the case of a static airfoil based on various icing circumstances.

First, the airfoil with the glaze ice attachment has a worse aerodynamic performance than the airfoil with the rime ice attachment.

Second, the longer the icing time, the larger the attachment's impact on aerodynamic performance. Third, leading-edge attachments have a bigger impact on aerodynamic performance than other positions.

Fourth, the attachment of glaze ice type is more easily controlled by the symmetrical airfoil, while the attachment of rime ice type is more easily influenced by the asymmetrical airfoil. The flapping airfoil is likewise supported by the first three results. There are, however, some distinctions between flapping and static Airfoils. The attachments on the trailing edge of flapping Airfoils, in particular, degrade aerodynamic performance. The aerodynamic performance of the asymmetrical airfoil with attachments derived from either rime ice type or glaze ice type is all worse. In most situations, the attachments produced in varied icing conditions degrade the aerodynamic performance of the airfoil. As a result, it is critical to continue developing effective icing technology to increase the operation life and performance of wind machines in the future.

9. Slotted Airfoil with Control Surface Neal J. Pfeiffer June 25-29, 2018.

The usage of slotted Airfoils for sailplanes and general aviation aircraft will be discussed in this study. The gap between a primary and secondary element is always open. This second component will serve as a control surface as well.

The main objective is to design and fabricate an UAV for improved endurance. The Endurance depends on the power and the aerodynamic performance.

A slot between the elements of a two-element airfoil has been engineered to remain open during all phases of flight. By using a simple hinge situated outside the second element's surface, the second element can be used as a flap or an aileron. With zero flap deflection and a typical lift increment with flap deflection, this airfoil idea allows for a high maximum lift with no flap deflection. Low drag can be achieved with today's computational design methods. The airfoil has traditionally been assumed to be a closed surface for the majority of the working envelope. To give more lift, one or more slots may be opened for take-off and landing, but leaving the slot open during cruise flight would result in an enormous drag penalty.

Engineers can carefully develop and assess a wide range of slot alternatives using modern computational airfoil design methodologies. Low-drag, slotted airfoils have been demonstrated through design and analysis using these methods.

Furthermore, with proper slot design, the second element can function as either a flap to increase maximum lift or an aileron to regulate roll.

A slotted airfoil can be constructed to:

- Give a higher baseline $C_{l_{max}}$ than a single-element airfoil of the same thickness.
- Provide a fair increase in lift coefficient with flap deflection.
- Have laminar flow and low drag, and
- Act as a simple, effective control surface.

This study's airfoil was developed to have a lower cruise lift coefficient range than a normal racing sailplane. It can be however readily covering the sailplane design range and more with a minor flap deflection. A slotted airfoil is a realistic design for light aircraft, especially sailplanes, according to this study. Slotted Airfoils can be constructed to have good lift and drag performance while also having benign stall characteristics for increased safety.

These Airfoils can be thicker than single-element counterparts, resulting in a lighter, more efficient structure. The use of a simple external pivot for the second element will also allow for the creation of low-cost flaps or ailerons. This notion could lead to the development of more efficient wings that are less expensive to manufacture than current designs.

10. Integrated Aerodynamic/Structural Design of a Sailplane Wing, B. Grossman, * Z. Gurdal, t G. J. Strauch, J W. M. Eppard, J and R. T. Haftka*Virginia Polytechnic Institute and State University, Blacksburg, Virginia SEPTEMBER 1988.

All the general gliders have large span and a very the large glide ratio, but the chuck gliders are small with less glide ratio, defining a scope for an impeccable glider.

The objective of this research is an investigation of the techniques and payoffs of integrated aircraft design. They have studied about the interaction of aerodynamic and structural design for a simple aircraft configuration of a sailplane wing. Utilizing elementary analysis tools, lifting-line theory, beam analysis, the geometry plan form, twist, along with the composite-material structural sizes (skin thickness, spar cap, and web thicknesses), comprising the variables, have been designed and it is subjected to the aero elastic, structural, and aerodynamic constraints.

The aeroelastic analysis is based on the equation of static torsional equilibrium of a straight wing about its elastic axis considering only the effects of torsional deformations on the lift distribution. They have investigated two design procedures. One of the designs is the Sequential Design, where the aerodynamic geometry is designed to maximize the performance of the sailplane and it is defined as the average cross-country speed, followed by a structural or aero elastic design to minimize the weight of the sailplane. The wing planform was defined by chord lengths at the root tip and at a point in between denoted the break, and the spanwise coordinate of the break. The weight is given to the aerodynamic analysis, and the process continues iteratively. The second procedure is the Integrated Design.

Here we simultaneously design the aerodynamics and the structural part of the sailplane. All design quantities have been determined simultaneously in a single optimization to maximize the performance or to minimize the weight. In all cases, the integrated design was superior in the terms of its performance or its weight to the sequential design. The integrated designs have been characterized by less rigid and high performance sailplane and its higher-aspect ratio wings that utilized the favorable aerodynamic or structural interactions. The aerodynamic constraints consisted of a maximum bank angle, a minimum climb speed, no stalling of the wing at any section,

and, for some cases, a performance constraint. We performed a series of design studies for sailplane wings to evaluate differences in the two design processes.

The strength of the thermal was an input parameter, and the results were found to be highly sensitive to this strength. Because sailplanes depend on their weight for speed during cruise, they often carry ballast to increase their cross-country speed.

11. Wing Design for Minimum Drag with Practical Constraints Tad McGeer.11, NOVEMBER 1984.

In this paper the study discusses techniques for selecting the spanwise lift, chord, and thickness to chord ratio (t/c) distributions of wings. The options are ideal because they reduce produced drag while meeting structural weight, parasite or compressibility drag, and the spanwise Cl distribution restrictions. Theoretical analysis is stability is given in this paper and to find the thermals to extend the endurance using the thermal soaring methods. General design characteristics of wings that is given in the minimum drag while satisfying the variety of practical constraints are sought out, including primarily a constraint upon structural weight. The essential elements of an aircraft are the aerodynamics and structures, when combined with analytical optimization, lead to a series of solutions for lift, chord, and thickness distributions across the span.

Although the optimized wings do not differ radically from the current practice in these distributions, they can offer significantly lower drag. For high subsonic wings of given structural weight, elasticity, and maximum load factor, forward rather than aft sweep promises a reduction in cruise induced drag of about 10% Wings whose weight is a large fraction of the total lift, as in sailplanes, may realize the larger reductions.

This paper presents about the algorithms for choosing the spanwise distributions of lift, chord, and thickness to chord ratio (t/c) of wings. The choices are optimal in that they minimize the induced drag while satisfying constraints on structural weight, parasite drag, or compressibility drag and the spanwise distribution.

These constraints play a key role for example, they cause the optimal lift distribution to depart from the familiar elliptical form Application of the algorithms is restricted to wings of at least moderate aspect ratio and has been designed for subsonic cruising flight.

Within the restriction, the results are dimensionless and cast in terms of a small set of constraints and parameters so they can be used for designs in which they range from the sailplanes to high speed transport aircraft.

As a result, advances above present practise are often underwhelming. Heavy wings, in which the wing weight accounts for a large portion of the total lift (say, more than 20%), are exceptional. By reducing some structural material from the tips of these wings (which are virtually exclusively seen in sailplanes), an induced drag reduction of up to 20% could be achieved. It is more beneficial to relieve than to carry the bending moment. When our methods are paired with the best sweep option for high-speed wings, the best results are obtained. The main conclusion of our high-speed optimization is that, in many practical applications, an optimised forward swept wing can offer significantly lower induced drag in cruise (say 10%) than an aft swept wing designed for the same load factor, even with elasticity typical of conventional design practise.

12. Long Distance/Duration Trajectory Optimization for Small UAVs Jack W. Langelaan August 16-19, 2007

A system for autonomous soaring flying by small and micro unmanned aerial vehicles is presented in this research. To enable exploitation of atmospheric energy via thermals, wave, orographic lift, or dynamic soaring, it combines a wind field forecast with a trajectory planner, a decision-making block, a low-level flight controller, and sensors such as the Global Positioning System and air data sensors. The primary goal of this study is to use orographic (slope or ridge) lift to enable long-distance, long-duration flights by a small unmanned aerial vehicle (UAV). This study describes a method for generating optimal trajectories that take advantage of the vertical component of wind to allow flights that would otherwise be impossible due to the UAV's performance limitations.

UAV aircraft is used for various purposes it may be any configuration. This paper presents that a system for autonomous soaring flight by small and micro uninhabited Aerial vehicles. It combines a prediction of the wind field with a trajectory planner, and a decision-making block, a low-level flight controller and sensors such as Global

Positioning System (GPS) and air data sensors to enable exploitation of atmospheric energy using thermals, wave, and orographic lift or dynamic soaring. The major focus of this research is about exploiting orographic (i.e., slope or ridge) lift to enable long duration, long distance flights by a small autonomous uninhabited aerial vehicle (UAV). This paper presents about a methodology to generate optimal trajectories that utilize the vertical component of wind to enable flights that would otherwise be impossible about the given performance constraints of the UAV. A point mass model is used to model the aircraft and a polynomial function which includes both the horizontal and vertical variations in wind speed is used to model the wind field. Both vehicle kinematic and minimum altitude constraints have been included. Results for a test case (crossing the Altoona Gap in Pennsylvania's Bald Eagle Ridge) are presented for both the minimum time and maximum final energy trajectories. A major limitation in developing practical small uninhabited aerial vehicles (uav) is the energy required for long-range, long endurance operations.

However, small, and micro uav's face severe limits on the fuel that can be carried out, greatly reducing both endurance and range. In addition, the best L/D attainable for small and micro uav's is typically much smaller than for larger aircraft because of the smaller Reynolds numbers. This further reduces performance of the aircraft. Significant range and endurance improvements can be realized by obtaining energy (in the form of altitude or speed) from the surrounding atmosphere. Energy can be obtained from vertical air motion, from velocity gradients and from gusts. Vertical air motion has three main causes: uneven heating of the ground, which produces buoyant instabilities known as thermals; long period oscillations of the atmosphere, generally called wave; and orographic lift, where wind is deflected by the slopes of hills and mountains. Vertical air motion is a quasi-static phenomenon, and flight which exploits vertical air motion is known as soaring.

Large birds such as eagles, hawks, and condors as well as human sailplane and hang glider pilots routinely use soaring flight to remain aloft for many hours and traverse hundreds of kilometers without flapping wings or the use of engines.

A second means of extracting energy from the air uses velocity gradients which can occur near the ground due to the boundary layer or shear layers and which it often occurs on the leeward side of mountains and ridges. Dynamic soaring is again

becoming the subject of research both for recreational flight mainly by RC flying enthusiasts and for uav flight. The third means of extracting energy from the air exploits gusts. It has been observed that the flight and the performance of large birds has been improved by gusts, while it is typically reduced on human-piloted aircraft.

Extracting energy from gusts is complicated by their typically short duration of time; hence very fast response (typically exceeding human reaction time) is required. Control laws have been developed to enable energy extraction from gusts by small uav's. These are the three methods of extracting energy from the environment can be used to enable the autonomous long duration, long distance flight (denoted as LD flight) by unmanned aerial vehicles.

This paper describes a technique for extracting energy from the atmosphere via small unmanned aerial aircraft. The autonomous energy extraction-enabled (LD)² (long duration, long distance) flight has the potential to greatly improve the ability of small and micro uavs to fulfil current missions and may allow these vehicles to perform tasks that are currently impossible due to range and endurance constraints planning to take advantage of atmospheric lift is an important part of (LD)² flight.

The methodology for generating these lift-exploiting trajectories was presented in this paper. The aeroplane is modelled as a point mass, and the flight is spatially discretized. Both vertical and horizontal wind components can be considered in a polynomial wind field.

13. The Design of a New Racing Sailplane: A New Thermal Mix Model and the Role of Transitional CFD. Mark D. Maughmer¹Christoph Wannenmacher³James G. Coder²Werner Würz⁴5-9 June 2017.

The purpose of the current study is to evaluate and apply a new approach to the design process of an aircraft with a high aspect ratio wing. The manufacturers of the commercial transport aircraft, sailplane manufacturers must also periodically introduce new designs to stay competitive mentality. Consequently, to stay competitive in the 18-Meter Class of racing sailplanes, the manufacturer, Schempp-Hirth Flugzeugbau, recently undertook the design of a glider to supersede its Ventus-2cx, first introduced in 2003. The resulting glider, the Ventus-3, benefited from a few game-changing

innovations that supported the design process, including the use of GPS in-flight logger data to develop a new model of the distribution of the thermals that are typically used in cross-country soaring flight. The use of modern optimization techniques now possible due to which the improved computer resources, and the use of computational fluid dynamics (CFD) methods that can now accurately predict the transitional aerodynamics so that it is important in the Reynolds number stream in which sailplanes can operate.

The design of the new sailplane was primarily performed in the classical manner using potential flow methods combined with two-dimensional airfoil aerodynamics. For the better understanding how the CFD methods can support the design efforts, the glider was analyzed using a computational fluid dynamics (CFD) solver that incorporates a recently developed transition/turbulence model. It was found that the design developed using traditional methodologies agrees very well with those obtained using CFD in the regions where the flow field is primarily two-dimensional. In some regions where this is not true, such as in the case of wing-body and wing-winglet junctions, a great deal of design insight can be garnered from the CFD results. In the case explored, CFD predictions demonstrated that the winglet airfoil needed to be modified somewhat from the results obtained using two-dimensional aerodynamics.

While the primary goal of any sailplane is its ability to simply stay aloft, which might be sufficient for some training sailplanes, the general measure of sailplane performance is determined by its ability to fly cross-country.

Although mountain waves and ridges are used in some parts of the world for cross-country soaring, the use of thermals predominates. In this regard, a typical cross-country flight is made up of a series of climbs in thermals. Clearly this performance is a trade-off between the very conflicting goals of being able to climb efficiently at low speeds in thermals against that of being able to glide efficiently at high speed between them. This challenging trade-off is explaining for the designer by the fact that both the climb and the glide are fully dependent on the weather of any particular day: the size, strength, and structure of thermals, the wind on course, the length soarable condition day, and so forth, the exploitation of a new soaring strategies in conjunction with technological advancements, such as laminar flow aerodynamics and material innovations, has yielded a gradual but steady increase in sailplane performance that

has resulted in the exceptional aircraft now flying. The introduction of accurate and reliable transition models into computational fluid dynamics solvers will have a significant impact on addressing features that are not well addressed by traditional methods.

14.3D aerodynamic analysis and optimization of a gliding locust wing using Nash genetic algorithm, HamidIsakhani* and Shigang Yue Caihua Xiong‡ and Wenbin Chen§.

Based on modern understandings and development in the fields of aerodynamics and computational fluid dynamics. This paper is based on modern understandings and development in the fields of aerodynamics and computational fluid dynamics. This study investigates the Aerodynamic characteristics of an insect species called desert locust (*Schistocerca Gregoria*) with extraordinary gliding skills at low Reynolds number. Here, locust tandem wings are subjected to a computational fluid dynamics (CFD) simulation using 2D and 3D Navier-Stokes equations Revealing fore-hind wing interactions, and the influence of their corrugations on the aerodynamic Performance. Furthermore, the obtained CFD results are mathematically parameterized using the PARSEC method parallax second and optimized based on a novel fusion of Genetic Algorithms and Nash game theory to achieve Nash equilibrium being the optimized wings.

It was concluded that the lift-drag (gliding) ratio of the optimized profiles were improved by at least 77% and 150% compared to the original wing. Ultimately, the profiles are integrated and analyzed using 3D CFD simulations that demonstrated a 14% performance improvement validating the proposed wing models for further fabrication and rapid prototyping has been presented in the future study. There has been an extensive research focus on tandem wings using various numerical theoretical, and experimental methods to better understand the underlying physical features facilitating their superior flight performance. This study performs a 2- and 3D digital reconstruction of a gliding-expert insect's (locust) wing to unveil the underlying physiological phenomenon responsible for its incredible flight performance.

A computational fluid dynamic modeling of the simulated airfoils and wings suggested geometrical features such as corrugations and fore-hind foil phase angle to be liable

for the high aerodynamic efficiencies obtained. Therefore, a novel bio-inspired optimization methodology based on Nash-GA algorithm is proposed to further improve the configuration and geometries of the wing profiles are digitized. Satisfactory 77% improvement of aerodynamic efficiency. As a result, a novel bio-inspired optimization methodology based on the Nash-GA algorithm is proposed to further optimise the digitised wing profiles' configuration and geometry. However, the optimized airfoils when integrated to form a 3D wing, delivered a 14% improvement when compared to its unoptimized counterpart. Ultimately, future extension of this study focuses on novel fabrication methods to realize the digitized wing designs into prototypes maintaining the presented numerically determined and optimized aerodynamic performance.

15. Midcourse Trajectory Optimization Method with Strong Velocity Constraint for Hypersonic Target Interceptor hang Danxu, Fang Yangwang, Yang Pengfei (2017).

The control and state parameters include lift coefficient, bank angle, positions, flight path angle, heading angle and airspeed. For intercepting the hypersonic target head on, the velocity of the hypersonic target interceptor besides angle, and the attitude, are the key points at hand-over time. Trajectory optimization is a practical method to provide satisfied states for the interceptor. Because of the limitations of the inertia constant of the missile body, the response time of an actuator, and tracking systems, all existing guidance and control methods are out of action for online computing and tracking to intercept the hypersonic target head-on when the relative velocity between a hypersonic interceptor and a hypersonic target is so large, such as above 10 Mach. The midcourse trajectory optimization is a practical way to improve the interception effect by providing optimal states for the HTI at the beginning of the terminal phase in case of a big miss distance.

At hand-over time, the velocity of the hypersonic target interceptor, along with angle and attitude, are the crucial points for intercepting the hypersonic target head-on. To decrease the large relative velocity at the hand-over time, and satisfy the angle and attitude constraints, this paper presented the hp-adaptive pseudo spectral method to

obtain the optimal trajectory of the interceptor. Firstly, specifically longitudinal plane motion equations for the interception are established, including the constraints on path parameters and terminal conditions are modeled. Secondly, using the hp-adaptive pseudo spectral method, the optimal problem is converted to a nonlinear programming problem with a series of algebraic constraints. Then the hp-adaptive strategy and algorithm flow represented. Simulation shows that the midcourse trajectory optimization method obtains the satisfied trajectory and terminal states. On the other hand, the results approach to the fact that the pseudo spectral method is more efficiency and Accuracy than conventional optimization method.

The paper's work provides a solid basis for breaking through the difficulty of the HTI (hypersonic target interceptor), intercepting the hypersonic target head on. When the relative velocity between the hypersonic interceptor and a hypersonic target are so large such as above 10 Mach, all existing guidance and control methods are out of action for online computing and tracking to intercept the hypersonic target head-on due to the limitation of inertia constant of missile body, the response time of an actuator and tracking systems etc. To provide perfect states for the HTI at the beginning of terminal phase in case of a large miss distance, the midcourse trajectory optimization is a practical method to improve the interception effect.

The HPM was presented in this paper in order to meet the high accuracy and quick computation requirements. The following is a summary of the paper's main contributions. At hand-over time, the HTI's huge velocity is reduced to the given value by the HPM, in the sense that the trajectory optimization method overcomes the strong velocity constraint problem and prepares the HTI's guiding law design for intercepting head on. Furthermore, the work in this paper lays a solid foundation for overcoming the difficulty of the HTI intercepting the hypersonic target head-on, that is, in longitudinal plant, using the optimal trajectory obtained by the presented HPM as guidance commands, and in horizontal plant, using the other advanced guidance law to ensure the hand-over requirement. This is the writers' next step in their research.

16. Refinement of Glider Aerodynamic Design using CFD. Johannes J. Bosman

The PSEUDOSPECTRAL method and boundary intersection method is used to increase the glide ratio.

When we are existing design and analytical methodologies, only minor aerodynamic improvements are attainable on present sailplane designs. To achieve a significant improvement in cross-country performance, areas that are not fully optimised must be addressed. These are places with complex surface flows that necessitate the use of specialised analysis methods. New breakthroughs in CFD laminar to turbulent transition modelling enable optimization of complex three-dimensional flow zones like the wing-fuselage junction.

The total performance improvement was compared to a baseline sailplane to highlight the overall effect of applying CFD to optimise several minor locations around the sailplane. An 18m Class sailplane's potential performance gain was calculated and determined to be roughly 3 glide-ratio points. Many designers and researchers believe that without features like boundary layer suction, improving the aerodynamic performance of existing sailplanes is difficult. The question then becomes whether new sailplane models with these features can achieve significant performance improvements over earlier designs without them. If just aerodynamic performance is considered, a sailplane manufacturer must enhance its glide ratio by at least two points before attempting to produce a new model.

This innovation enhanced the spanwise load distribution, which had to be close to elliptical to have the least amount of induced drag. Further adjustments to the root profile were made to ensure a somewhat unfavourable pressure gradient on the upper root surface, which would lessen separation issues. Due to the limits on span and stall speeds, further improvements to the planform and aspect ratio are unlikely. In order to get more cross-country performance out of an 18m-Class sailplane, areas that haven't been fully optimised must be addressed.

In general, these are areas with complex surface flows that necessitate the use of specialised analysis methods. While some of the qualities mentioned above are straightforward to achieve, others, such as the high-wing design, necessitate considerable geometry adjustments. The next generation sailplane, however, may

become a reality with the latest CFD capability—and with this example set of drag reduction features, the overall drag reduction can be as much as 50%.

17. A CFD-Compatible Transition Model Using an Amplification Factor Transport Equation James G. Coder¹ and Mark D. Maughmer²⁰⁷ - 10 January 2013

The basic objective for this paper is the aerodynamic flow over the various airplanes, sailplanes to see the aerodynamic flow over the particular model.

For low-turbulence exterior aerodynamic applications, a new laminar-turbulent transition model is created that includes linear stability theory in a way that is consistent with recent CFD solvers. In the presence of a boundary layer, the model employs a new transport equation that represents the increase of the maximum instability amplitude. A locally determined non-dimensional pressure gradient parameter is used as an estimator of the integral boundary-layer properties, avoiding the need for integration pathways and non-local operations.

The OVERFLOW 2.2e solver has been updated to include the model. Predictions made with the new model compared to high-quality wind-tunnel measurements of airfoil section properties show the model's predictive abilities, as well as its advancement over the present state of the art in CFD transition modelling.

In computational fluid dynamics (CFD) simulations of aerodynamic flows, accurately estimating the location of the laminar-turbulent transition is critical, since the extent of laminar flow can have a considerable impact on the drag and maximum lift predictions for an aerodynamic body. The new transition model successfully integrates linear stability analysis, specifically the evolution of Toll mien-Schlichting waves, with RANS CFD, as evidenced by positive comparisons with analytic flat plate solutions and high-quality wind-tunnel airfoil data. The novel transition model meets the requirement of being CFD-compatible by requiring just local information and free-stream flow conditions (which are independent of both the grid and the solution). The new model was compared to the previous, state-of-the-art Langtry-Menter transitional turbulence model, and the new model outperformed the old one in terms of profile drag prediction.

The new model is substantially more accurate in predicting the low-drag lift coefficient range, which appears to be owing to an improved sensitivity to transition in associated boundary layers in unfavourable pressure gradients.

This is a significant advancement in the state of the art in terms of using CFD for aircraft design, as precise prediction of the lift-drag relationship is vital to the design process. In comparison to the Langtry-Mentor model with identical convergence features, the new transition model requires less CPU time per time step.

The new transition model still needs a lot more development. The application of this transition model to various eddy-viscosity turbulence models is an immediate next step in the development of this transition model, allowing the freedom to choose the turbulence model that is most appropriate for a given application.

To extend the transition prediction capabilities beyond Toll mien-Schlichting instabilities at low free-stream turbulence levels, more work is needed. The inclusion of transition via crossflow instabilities, which is the fundamental transition mechanism on swept-wing aircraft, is the most essential of them. Although the current version of the model creates greater amplification in the presence of cross flow, more research is needed to see if this is enough for general use. By combining amplification correlations with local correlations, it is also possible to add bypass transition in the model for higher turbulence levels. Both the crossflow and bypass transitions are expected to be second-order effects that do not necessitate changing the current amplification correlations' behaviour.

**18. Aerodynamic Analysis of a Dragonfly. Shiva Prasad Uppu¹, Dindigala Manisha¹, Gudey Dharani Devi¹, Pranav Chengalwa¹, Boppana Vaishnavi Devi¹
Received 21 June 2018 Received in revised form 20 October 2018 Accepted 28 October 2018 Available online 6 November 2018**

The main objective of the paper is the facilitate transportation and to land it to the destination point. The goal of this study is to compare the corrugated dragonfly airfoil to the typical smooth NACA 2.5411 airfoil in terms of aerodynamic qualities. The current study examines a reduced dragonfly airfoil at low speeds. The results of a 3D printed model are compared to the NACA 25411 airfoil using a Six Component Strain

Gauge. The results are compared to the conventional section by evaluating aerodynamic performance at low Reynolds numbers. Both experimental and numerical work is carried out on the model at various wind speeds and angles in order to streamline the results. The data acquired sheds light on the model's mechanics, which revealed a completely nonlinear behaviour that resulted in positive aerodynamic forces.

Numerical analysis is a technique for determining and analysing the solutions to diverse fluid flow problems using mathematical formulations. Though it offers advantages such as not requiring a physical setup, it also has drawbacks such as comprehension, mathematical modelling, and processing power availability.

Furthermore, the findings acquired with this technique may be approximate rather than exact solutions. Computational Fluid Dynamics (CFD) is an application of numerical techniques in which flow conditions are simulated and evaluated using supercomputers, which are more advanced, accurate, and rapid than human operations.

According to the flow model defined, the Navier-Stokes equations are the foundation of CFD problems, from which many additional equations such as Euler equations, full potential equations, and linearized potential equations are formed. A Wind-Tunnel Test or a full-scale flying test can be used to validate the CFD results.

The Dragonfly Airfoil offers better aerodynamic characteristics, such as high C_l and C_l/C_d , because of both numerical and experimental analysis results. Because of its corrugated cross-section, the Dragonfly Airfoil clearly has greater C_d than the NACA 2.5411 Airfoil. However, the advantages it provides in terms of producing lift are greater, as evidenced by the high lift-to-drag ratio. The vortices formed at the troughs in the cross-section of the Dragonfly Airfoil are thought to be responsible for the high lift. The vortices generate negative pressure, and AOA larger than 0 might result in a net negative pressure on the upper surface.

As a result, when the Dragonfly Airfoil is operated at an AOA, it generates additional lift. The data paves the way for more study to be done using this baseline data to analyse the entire fly wing by combining the current data with the full sections.

19. An Indirect Method for Optimal Guidance of a Glider Romain Pepy, Bruno Hérissé August 24-29, 2014

Having a light and compact design is important since it is a glider without an engine and it uses power only for the transmission of sensory data. The goal of this work is to discover a glider trajectory that optimises the ultimate velocity while respecting both the beginning and terminal state constraints. The system is governed by a new set of differential equations determined using optimal control theory. An algorithm based on an indirect shooting method is provided to solve this system of equations. It generates pathways with a final speed that is higher than that obtained by a commonly used closed-loop approach. The aim of this analysis is to provide a new glider guidance system. Gliders are unpowered aircraft that manoeuvre by using the aerodynamic forces generated by their tail fins or wings.

Many flying devices, such as sailplanes, rockets, and missiles in their non-propelled phases or high-speed gliders, can be classified as gliders. A glider must sustain its speed in order to extend its range. To put it another way, it must reduce the drag force along its trajectory while preserving sufficient lift to manoeuvre and reach the target position. The guidance technique we present in this study is effective for any glider that flies fast enough to ignore gravity. It ensures boundary limits on both position and orientation, as well as maximising the system's final velocity. It considers the glider's moving through a diverse environment. When the glider climbs, the density of the air changes, reducing the effects of both drag and lift forces.

The most widely utilised solutions for resolving such a challenge come from the missile guidance community. These guidance laws simplify the problem so that an analytic solution can be found, and a fully closed-loop guidance law can be obtained. Because these principles need little calculation time, they can be embedded on real gliders and used to compute control inputs in real time. They consist of a proportional navigation term that pushes the vehicle towards the final position and a shaping term that allows the vehicle to arrive at the final place with the desired orientation. These laws are highly traditional.

However, the multiple approximations need to arrive at an analytical form mean that the final trajectories are frequently far from ideal. The kappa guidance law, which maximises the end velocity of an unpowered system under certain simplifying assumptions, is arguably the most well-known. Other closed-loop guidance laws that use singular perturbation theory are described in section Other closed-loop guidance laws that use singular perturbation theory are described in section

This work introduced a new indirect approach for determining the best glider trajectory between two states that optimises the glider's terminal velocity. Optimal control theory is used to derive guidance equations. An indirect shooting mechanism is used in a simple implementation. The findings show how well our indirect method performs in comparison to current fully closed-loop solutions. Future work will concentrate on reducing the time it takes to compute a path and making the method more resistant to start-up errors.

20. Gliding Research – An Important Incubator for the Entire Aviation Juergen Thor beck 6 - 13 August 2008.

The emergence of unmanned air vehicle UAV and micro air vehicle MAV, the aerodynamic characteristics of airfoil for Reynolds number less than 5×10^5 is becoming actively important there by making the area of high-lift airfoil as a topic of great interest. Gliding research, written from a German perspective but applicable worldwide, has made significant contributions to aviation technology, such as the invention of composite structures and laminar flow. Gliding research has served science, society, and industry as a generator of ideas, a platform for both experiments in many fields of technology and fundamental and applied aerodynamic research, and a provider of highly motivated offspring researchers and industry engineers for the entire aeronautical community since its inception at the turn of the twentieth century. Significant persons and their efforts, as well as the contributions of German academic flying groups, are identified.

CHAPTER NO: 3

AIM AND SCOPE: -

The aim of this research is to optimize the performance of the glider to give good results in its flying process. To achieve this expected result, we are using various methods and software to optimize the structural sandwich panel method and aerodynamics of the sailplane design. The scope of this project in future the sailplane can be used for as same as drones.

3.1 SOFTWARE REQUIRED FOR DESIGN:

INTRODUCTION TO CATIA V5:

CATIA (Computer Aided Three-dimensional Interactive Application) is a commercial CAD/CAM/CAE software suite developed by Dassault Systems in France. CATIA is the cornerstone of Dassault Systems' product lifecycle management software suite, written in the C++ programming language. Siemens NX, Pro/E, Autodesk Inventor, and Solid Edge, among others, compete with CATIA in the CAD/CAM/CAE sector.

CATIA began as an in-house creation in 1977 by Marcel Dassault of Avion, a customer of the CADAM CAD software at the time to construct Dassault's Mirage fighter plane, and has since been embraced by the aerospace, automotive, shipbuilding, and other industries.

History of Catia:

CATIA (Conception Assisted Tridimensional Interactive - French meaning Interactive Aided Three-dimensional Design) was renamed CATIA in 1981, when Dassault founded a subsidiary to develop and distribute the software, and IBM signed a non-exclusive distribution deal. The Boeing Company picked CATIA as its primary 3D CAD tool in 1984, becoming the company's largest customer. CATIA version 3 was converted to UNIX from mainframe systems in 1988. General Dynamics Electric Boat Corp used CATIA as its primary 3D CAD tool in 1990 to design their boats. General Dynamics Electric Boat Corp used CATIA as its primary 3D CAD tool to design the

Virginia class submarine for the US Navy in 1990. CADAM was purchased from IBM in 1992, and CATIA CADAM V4 was released the following year. In 1996, IBM AIX, Silicon Graphics IRIX, Sun Microsystems SunOS, and Hewlett-Packard HP-UX were among the four UNIX operating systems that were ported. CATIA V5, a completely redesigned version of CATIA, was launched in 1998, with support for UNIX, Windows NT, and Windows XP beginning in 2001. Dassault announced and released CATIA V6 in 2008. While the server can run on Microsoft Windows, Linux, or AIX, any operating system other than Microsoft Windows is not supported by the client.

Scope of Application:

CATIA is a 3D Product Lifecycle Management software suite that supports several stages of product development (CAD), including concept, design, manufacturing, and engineering (CAE). CATIA helps engineers collaborate across disciplines, such as surfacing and shape design, mechanical engineering, and equipment and systems engineering. Designing the Surfacing and the Shape. To develop, alter, and evaluate complicated novel shapes, CATIA offers a suite of surfacing, reverse engineering, and visualization technologies. From subdivision, aesthetics, and Class A surfaces to mechanical functioning surfaces, there's something for everyone. Mechanical Engineering is a branch of engineering that deals with machines.

From 3D sketches, sheet metal, composites, moulded, forged, or tooling pieces, through the description of mechanical assemblies, CATIA enables the development of 3D parts. It includes tools for completing product definition, including functional tolerances and kinematics. Design of the Equipment: CATIA makes design easier. CATIA helps with the design of electronic, electrical, and distributed systems like fluid and HVAC systems, as well as the development of manufacturing documentation. Engineering of Systems: Through a system engineering methodology, CATIA provides a solution for modelling complex and intelligent goods. It includes requirements definition, systems architecture, behavior modelling, and the creation of a virtual product or embedded software.

Application programming interfaces (APIs) allow CATIA to be customized (API). CAA (Component Application Architecture), a component object model (COM)-like interface, can be used to modify CATIA V5 and V6 utilizing Visual Basic and C++ programming languages. Although later versions of CATIA V4 included NURBS, the

original version relied heavily on piecewise polynomial surfaces. CATIA V4 has a solid engine with no manifold. Catia V5 has a parametric solid/surface-based modelling system. CATIA helps with the design of electronic, electrical, and distributed systems like fluid and HVAC systems, as well as the development of manufacturing documentation. Systems Engineering: CATIA's systems engineering approach allows you to model complex and intelligent goods. It includes requirements definition, systems architecture, behavior modelling, and the creation of a virtual product or embedded software.

Introduction to star ccm+:

Simcenter STAR-CCM+ is a commercial Computational Fluid Dynamics (CFD) based simulation software developed by Software. Star ccm+ software is user friendly software for the cfd analysis of a specific or required cad model and it shows the flow of fluid simulations in a preferred way. Star ccm+ gives the simulation of flow quickly and accurately. Simcenter STAR-CCM+ allows the modeling and analysis of a range of engineering problems involving fluid flow, heat transfer, stress, particulate flow, electromagnetic and related phenomena. Commonly known as STAR-CCM+, the software was first developed by CD-adapco and was achieved by Siemens Digital Industries Software as part of the purchase of CD-adapco in 2016. It is now a part of the Simcenter set of software tools.

History of star ccm+:

Historical development on the work in STAR-CCM+ was started after a decision which was taken to design a new integrated user friendly CFD tool to replace the existing product STAR-CD which have been developed during the 1980s and 1990s by Computational Dynamics Limited, a spin-off company from an Imperial College London CFD research group. STAR-CD was widely used on most of the automotive industry and aeronautical industries. STAR-CCM+ aimed to take the advantage of more modern programming methods and the systems to provide an wide framework.

STAR-CCM+ was announced at the 2004 AIAA Aerospace Sciences Conference in Reno, Nevada USA. A unique specific feature was a generalized polyhedral cell formulation, allowing the solver to handle any mesh type imported method. The first

official release included the first commercially available polyhedral Mesher which offers the faster model convergence compared to an equivalent tetrahedral mesh method is used in the meshing of the star ccm+ application.

Software overview:

Simcenter star ccm+ is a computational fluid dynamics (cfd) software used for the analysis of flow dynamics for the required 3d cad model. The model is been imported to the software in a STP file format. The boundary conditions for the model has been given. So that the flow of air has been categorized and the model is inserted for further stages of analysis.

Stage 1:

Geometry:

The geometry is the first stage of the analysis. After giving the boundary conditions for the model the model has been inserted into geometry and the region for the model is given. The regions is given for each part of the model. The boundary conditions of the model are given in this stage for the model. The model geometry has been on set.

Stage 2:

Meshing:

At the same geometry stage, the base size of the model has been given and in the operations bar. The base size is the main key for the meshing stage. The tetrahedral meshing model utilizes the tetrahedral cell shape which is to build the core mesh. In Simcenter STAR-CCM+, the method is efficient and has been used to construct the mesh, which iteratively inserts points into the domain, forming high-quality tetrahedral in the process. The polyhedral mesh has been used for the meshing stages for the model. The mesh quality has been checked and it has been moved to further stages. If the quality is not fine meaning the base size is been changed so that the mesh quality will be in a considerable built quality. The quality has been checked using the amount of breakage in the model. Then the physics of air flow for the model is to be given for the simulation.

Stage 3:

Scalar:

The scalar is the third stage of analysis. This stage is used to analyze the model flow simulation in a clear way. For doing the scalar the reports are need to be generated for the analysis. The reports are the main reading for the analysis. For generating the report, we should click the left corner toolbars, the report can be generated. The coefficient of lift (cl), coefficient of drag (cd), and coefficient of moment (cm) is the general required reports for the model. Then the monitors are created for the reports so that the flow graphs of cl, cd and cm can be seen in the monitor graphs. the section plane should be given for the model for creating the scene plot for the flow analysis. The plane is the main scene for the flow analysis so that the air flow can be visualized in the model. the color graph should be checked for the flow simulations for the model. then the model is moved to the final stage.

Stage 4:

Vector:

This is the final stage for the cfd analysis. This stage is quick stage of checking the entered data is correct or needed to be corrected. The scene plot has been again included in the vector scene so then the scene plot will be analyzed. The color graph has been checked and then the flow analysis has been started and once it is completed the model flow simulations is visualized in the scalar and vector scene. The graphs are being monitored in the monitor graphs, and the final coefficient of lift, drag and moment has been found out using the monitor from report toolbar. Thus, the cfd analysis for the required model has been checked and completed.

TYPES OF CELLS

- Engineering Data
- Geometry
- Model/mesh
- Setup
- Solution
- Results

GETTING STARTED TO STAR CCM+

STEP 1: launch STAR CCM+, by going to start up menu and double clicking on Workbench file in the STAR CCM+

STEP 2: Once the program is launched it should look with some toolbox. Go to the analysis system fluid flow and double click

STEP 3: Next double click on the geometry. This stage is for reading the required geometry into the software; note that the geometry text has a blue question mark icon beside it. Looking at the bottom of the window, you'll see two windows: one with the title Messages, which indicates that the imported geometry is working properly, and the other with the title Status.

STEP 4: When the window is active, you'll be presented with a window where you can specify the working units for the model dimensions. Choose meters and press OK. The smaller the box size, the finer the mesh, and the more accurate the data captured.

STEP 5: Go to the file and choose to import external geometry file (STP type file).

STEP 6: The user will see a window with a title open, select Fil type Parasolid, and then navigate to the folder that contains the required file.

STEP 7: looking at the design modeler window, we can't see the imported Geometry yet, press the generate icon.

STEP 8: Select wireframe from the view menu.

STEP 9: Once we finished that stage means we have finished from Designer model and must proceed to meshing part.

STEP 10: The meshing part of the project has started, notice the beside Mesh icon.

STEP 11: Select tetrahedrons from the technique drop-down menu.

STEP 12: Go to the algorithm and choose patch independent.

STEP 13: Press the update icon, then the produce mesh button.

STEP 14: Click on mesh to make the created mesh visible to the user.

STEP 15: Go to the workbench and you'll notice a green tick beside the mesh.
Congratulations, you're ready to start setting up.

The Menu Bar and the Tool Bar

- Open a new or existing product
- Save a project under the same name
- Reconnect to any pending updates from before the project was closed
- Refresh a project
- Update the project
- Imports a legacy database
- Set your workspace to compact or full mode
- Return to standard project workspace view

The menu bar provides access to a variety of options

- File menu
- View menu
- Tools menu
- Units' menu
- Help menu

Making use of the chart view

- Types of graphs
- Changing the chart's properties
- Zoom, pan, and rotate the chart
- Making use of the triad
- Keeping a graph

Any sort of load can be given to the solid model, and after meshing, the diagram now shows the stresses operating at each place, with color variation between different types of stresses.

CHAPTER NO:4

Design of sailplane glider:

4.1 Wing Design: -

In the design of the wing depicts the glider model and Sandwich Panel, as well as the materials which are in the design model. The lift coefficient CL required must be computed according to the maximum pre-designed glider's model specified mass regarding to identify the glider's dynamic behaviour. The glider's thrust force, as well as the drag coefficient CD acting on it, should be observed while it is gliding. Then it's time to figure out CL , which is required in relation to the glider's maximum estimated mass. By determining the CD_0 , the maximum hovering speed V_{max} (m/s) can be calculated. In the dynamic characteristics of a low Reynolds number sailplane, airfoil selection is critical. The efficiency of a curved wing is higher than that of a flat wing. Air flows smoothly over the top, resulting in lower pressure and reduced drag. As the air flows over the top, it gets turbulent, resulting in an inefficient flat wing. Turbulence causes more drag and as a result less lift seen in the diagram. Because of its optimal cambered wing design structure to provide higher glide ratio, the airfoil FX74 CL 140 MOD was chosen for the sailplane. Different airfoil configurations are compared. The airfoil FX74 CL 140 MOD is the most utilised for sailplane manufacture because it enhances lift on one side while lowering drag on the other for improved flight. Camber is added to the airfoil to improve lift at low speeds; however, as the lift coefficient increases, the stalling speed of the sailplane decreases.

When compared to aircraft with symmetric airfoil sections, aircraft with cambered wing designs have lower stalling speeds. The tapered wing, on the other hand, has a lesser lift force but better dynamic stability. As a result, FX74 MOD was chosen for optimal design, and the coordinates of FX74 MOD were created and plotted using Airfoil Tool. The wing design as per the following norms required characteristics. The most essential factors in determining the geometry are the airfoil section, chord distribution, height, twist, sweep, and toe angle. The design problem is challenging since there are so many variables involved. The operating profile of a sailplane, which combines a low-speed, high-lift coefficient climb phase with a high-speed, low-lift coefficient cruising phase, both of which are approximately equal in importance, adds to the complexity. The purpose of the winglet airfoil design, like most airfoil designs, is to provide the desired lift with the least amount of drag. In the case of the winglet airfoil, the winglet's operating low-drag area should match that of the wing. Similarly, the winglet should not stall before the main wing in low-speed flight. Every wing/winglet combination has a unique relationship between the winglet lift coefficient and the main wing lift coefficient, and ideally, each combination would have a specially designed

winglet airfoil. In most circumstances, however, the tiny improvement in performance that would occur is insufficient to justify such an effort.

4.2 Sailplane 3D CAD Model:

The 3d cad model has been designed in the CATIA V5 design software. There is the two CAD model shown below. The sailplane model consists of a narrow thin fuselage, high wingspan, empennage structure with vertical and horizontal stabilizer. A glider or sailplane is a type of aircraft used in the ease activity and sport of gliding. The sailplanes are also used for soaring purposes. This unpowered aircraft will use the naturally occurring currents of rising air in the atmosphere to gain altitude. The sailplanes will use the thermals for gaining the altitude when the altitude naturally decreases. Sailplanes are aerodynamically stabled and so it can fly a significant distance forward for a small decrease in altitude. Generally, the sailplane model have high wing span with thin fuselage so that is can glide more distance, and can reach a notable distance with the structure.

Generally, a glider should be of low weight because gliders are powerless aircraft so that the model should cover a notable distance with the structure. In this project we have designed two models of sailplanes. One is the general conception design which describes our concept. The second model is the fabricated model. The second model has been fabricated using a 3d printer. The first conception model gives the concept of our design. The first model has been designed with a sandwich panel duct. the sandwich panel structure is the vent or chamber which is present in the sailplane which injects the air from the atmosphere with multiple layers of filters and has been connected to an air pump which pumps the air and lets out the air through an outlet valve.

The suction in the sandwich panel can be compared with many tiny holes larger and fewer holes in the folded core and even larger and fewer holes in the lower skin. The channel type structure enables cleaning the inner structure when pollen and dirt are sucked into the suction sandwich. The wings, fuselage structure, empennage structure has been designed in the conception design model. The model is designed in part design and by using the planes as needed. This design is designed in ZX plane cross

section. The sailplane which has the modification done on this design comparing with numerical designs of our work. This sailplane is designed from the fuselage part with the first plane with a minimum diameter of 0.55cm or 5.5mm and the diameter has been increased side by side. The maximum diameter or thickness for the fuselage is 10cm or 100mm. the thickness for the conception design has been minimum rate and the skid landing gear has been fixed below the fuselage in side of the sandwich panel vent. The fuselage dimensions from the starting point to the ending point are 1125.001mm.

The wing is designed in the same part design and using the multi sections the airfoil has been connected to a wing structure. Here in this particular part we have decided to use the fx74 cl140 mod airfoil because of its downwash design so that the pressure coefficient will be higher in this particular airfoil. The airfoil has the chord of 120.2mm with 100% thickness. This airfoil is used for sailplanes, motor gliders and wind tunnels. The airfoil downwash pressure difference is higher so that the lift is generated with small angle of attack. The cl/cd of this airfoil is 6.16 at an α of 6 degree. The airfoils are designed using the planes in required areas. Then the airfoils are attached using the multi sections tool in the part design. Using the scale option, the airfoil chord has been reduced and the winglet is designed. So, the wing in the conception design looks like the wing and the winglet are attached in one single design.

The skid landing gear is a rod like structure which is attached below the fuselage of the sailplane. This landing gear is used for the sailplane to land in the ground and the drag or friction of the landing gear will reduce the speed of the sailplane so that the sailplane will land properly and safely without any damage. The vertical and horizontal stabilizer of the sailplane conception design is attached in the fuselage final edge and the vertical stabilizer is attached in the center of the final edge of the fuselage. The length of the sailplane vertical stabilizer is higher in the conception design model. Fabrication design model is the second design which we have designed. In this design there are some changes carried out by comparing numerous designs which we have done. The fabrication design has some size changes than the conception design. The thickness of the fabrication design model is higher because it should be experimentally tested in the wind tunnel. The wind tunnel testing is done for the model

so that the model characteristics of the model are analyzed and determined. The fabrication model holes are put in the wing and the fuselage area for the testing. The holes are taken from the wing and passed to the fuselage area. The total length of the fuselage is 130mm. the wingspan length is 180mm. this size of the fabrication is smaller than the conception design because of testing process. The model is fabricated using the 3d printer wit PLA filament. This filament is lighter but stronger. The strength of the fabricated model is quite higher so that it can withstand the air flow on the wind tunnel.

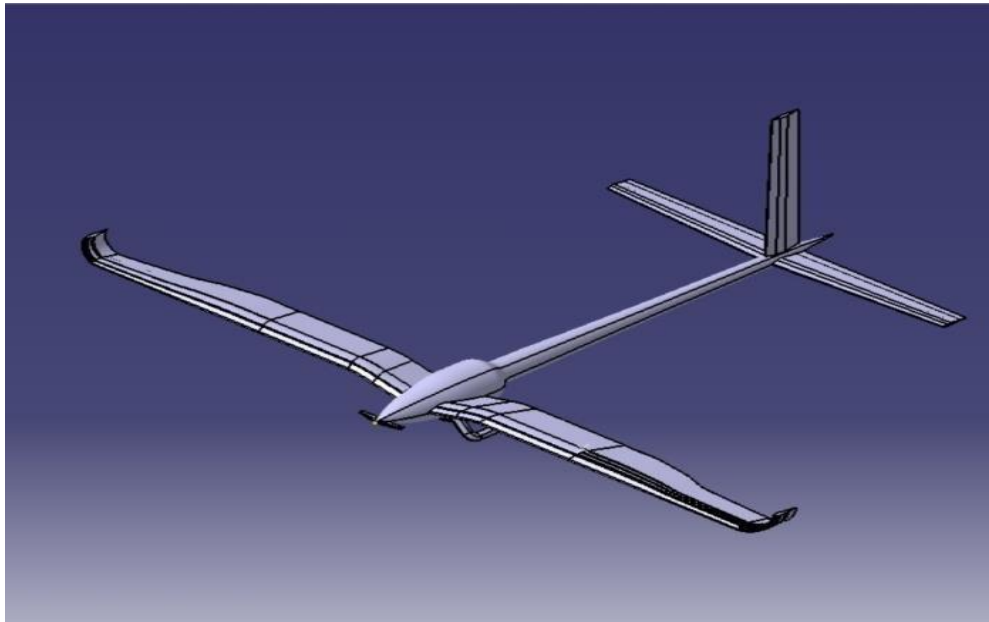


Fig. 1.1 ISOMETRIC VIEW OF SAILPLANE

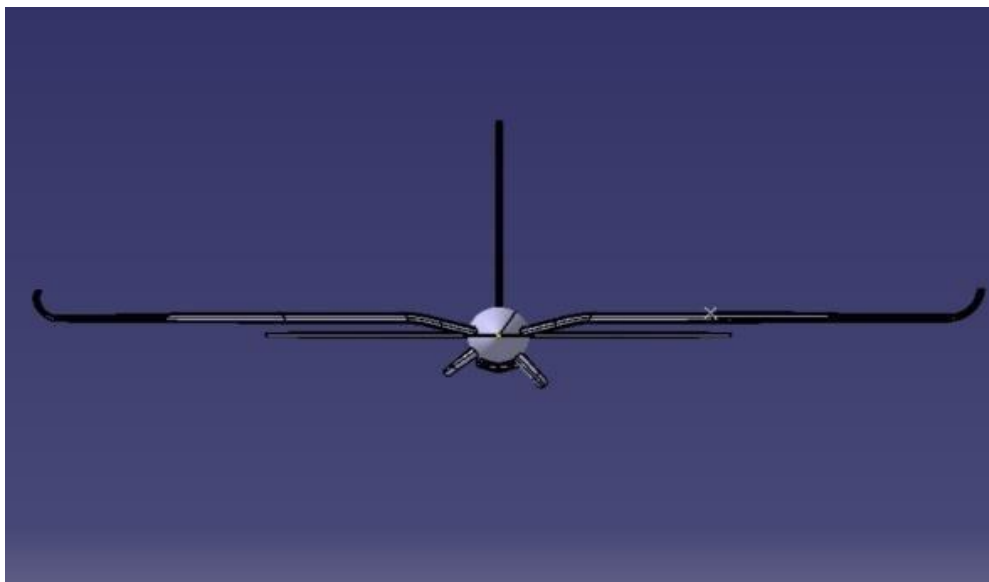


Fig. 1.2 FRONT VIEW OF SAILPLANE

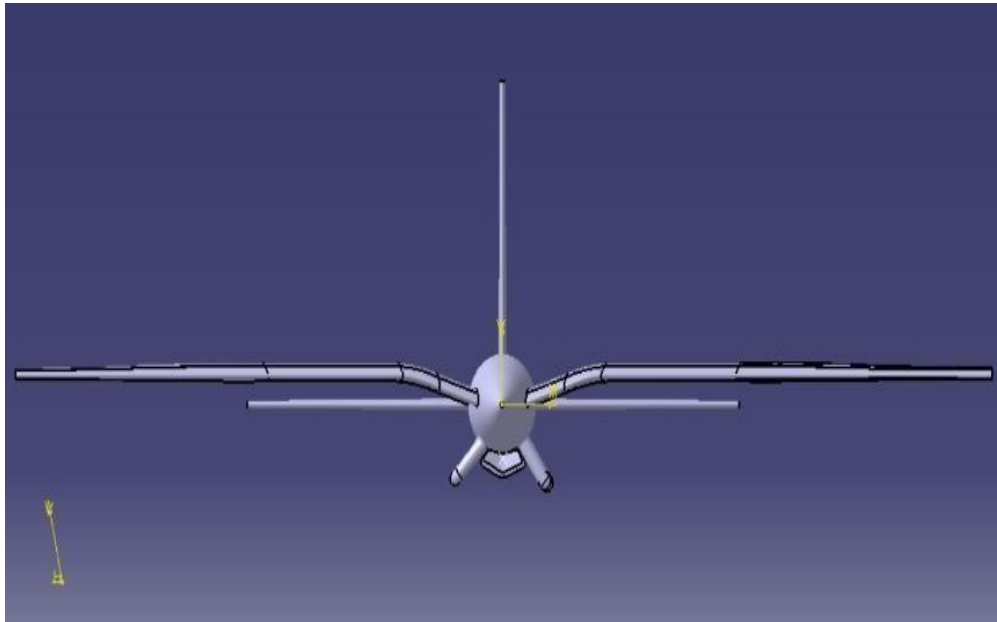


Fig.1.3 FRONT VIEW OF SAILPLANE DESIGN

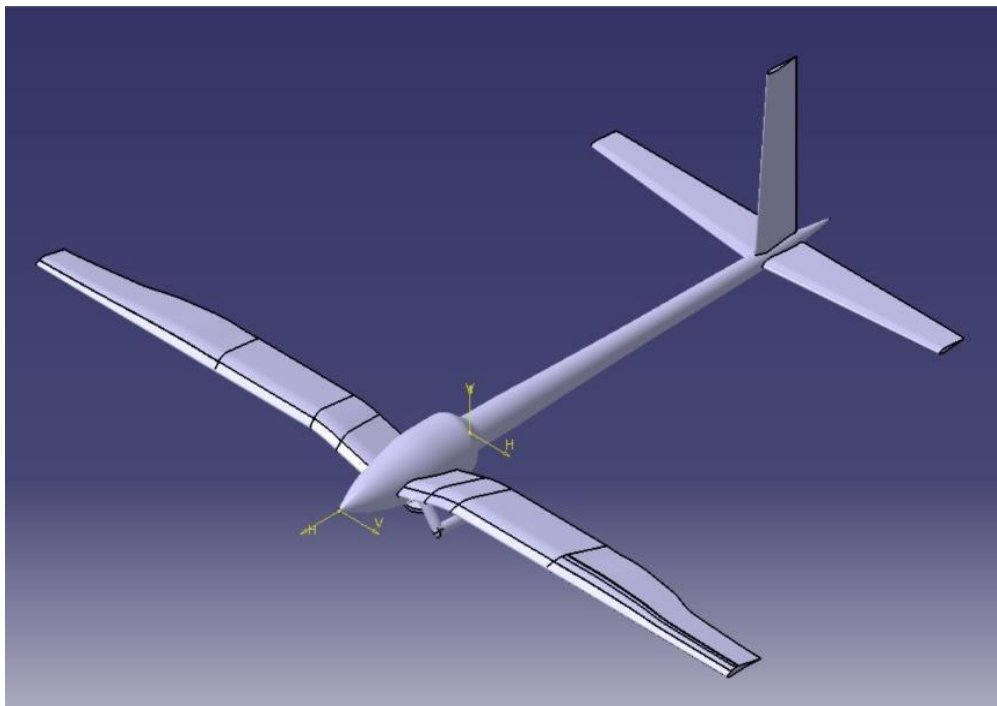


Fig. 1.4 ISOMETRIC VIEW OF SAILPLANE

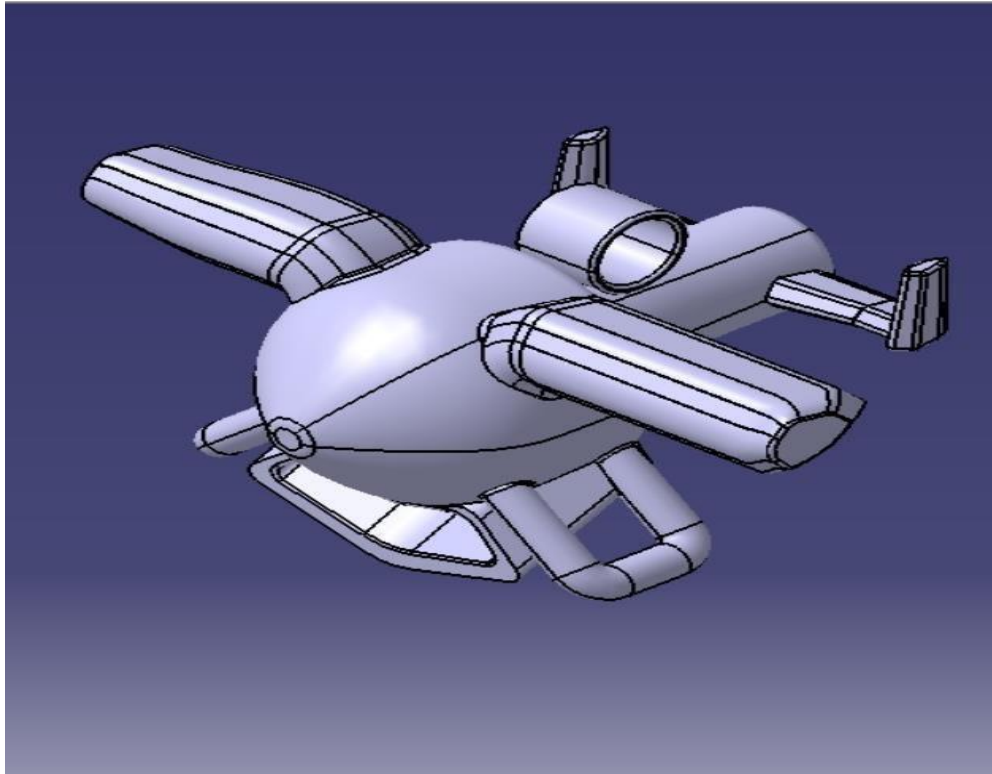


Fig.2.1 ISOMETRIC VIEW OF EXPERIMENTAL DESIGN

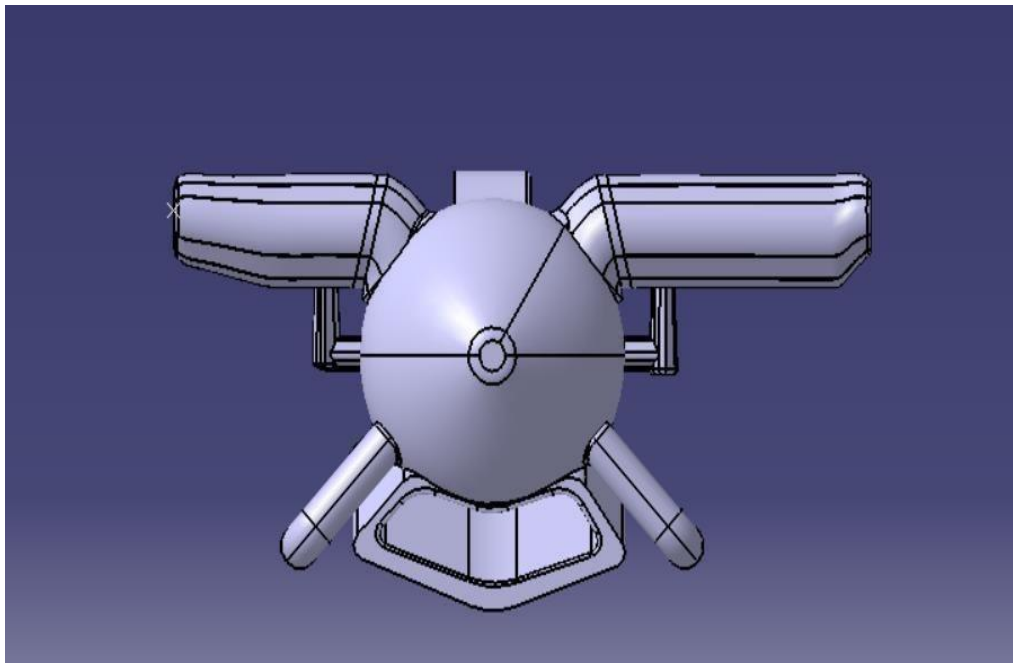


Fig 2.2 FRONT VIEW OF EXPERIMENTAL DESIGN

CHAPTER NO:5

Analysis

It is also worth noting that the information needed to guide airfoil design is influenced by the winglet geometry, which is influenced by the aerofoil's aerodynamic characteristics. As a result, the winglet/airfoil design process is iterative, with the final product being the culmination of several design iterations. As a result, in addition to an accurate airfoil design approach, an accurate way of analysing the impact of winglet design features on total sailplane performance is also required. The narrow chords and resulting low Reynolds numbers make achieving the required design goals for the winglet more difficult. This condition creates a trade-off between trying to reduce the wetted area growth by using small and trying to reduce the wetted area rise by using large. Although not as important, the spanwise chord distribution should be such that the loading on the winglet is almost elliptical and the resultant drag on the winglet itself is reduced once the fundamental chord dimension has been calculated.

A number of competing factors influence the most appropriate winglet chord distribution. Most importantly, the winglet must be able to create the spanwise loading required for a beneficial interaction with the main wing's induced velocity field. Very short winglet chords can necessitate lift coefficients greater than the airfoil can provide at low flight velocities. This, of course, renders the winglet ineffectual and can result in excessive drag as a result of the stalled winglet. Winglet chords that are too large, on the other hand, might result in poor performance because excessive stress on the winglet can overload the main wing's tip area and reduce its plan form efficiency. All of these approaches have sought to quantify the trade-off between the profile drag penalty and the induced drag benefit in some way. All previous efforts used what is known as the crossover point on the sailplane speed polar prior to the current method. The airspeed at which the flight polar of the base aircraft and the aircraft with winglets overlap, or where the percent change in sink rate owing to the winglets is zero, corresponds to this position. Winglets are advantageous below this speed; however, they are detrimental above this speed. As a result, the crossover point is the speed at which the induced drag benefit from winglets equals the profile drag cost. The geometry of the winglet can be used to influence the crossing point once it is understood.

The crossover point was selected to be higher than any anticipated cruising speeds in the early phases of adopting this simple principle. Although based on a simple theory, the employment of this formula resulted in winglets that generally increased performance and was as good as the "not so good" capacity to forecast changes in

induced drag owing to changes in winglet geometry. The crossover point approach was changed to take use of improvements in the capacity to forecast induced drag for a given wing geometry. These approaches were used to design, build, and test a variety of winglets, and while they were based on simple notions, they helped to create the following rules of thumb. First, it is advantageous for the design to be "out-of-plane," whether with up-turned tips or winglets. The Analysis of the following sailplane with the proper design conditions been analysed using the STARCCM+ software for CFD analysis. The following modal has been tilted to various angle of attack and analysis of that STAR CCM+ software. The Angle of attack has been change in the design software and has been analysis in the STAR CCM+ software. In the analysis the base size we have been reduce till sailplane modal mesh is good. After that in the STAR CCM+ for meshing under physics of the modal then after successful analysis we process for 3D printing.

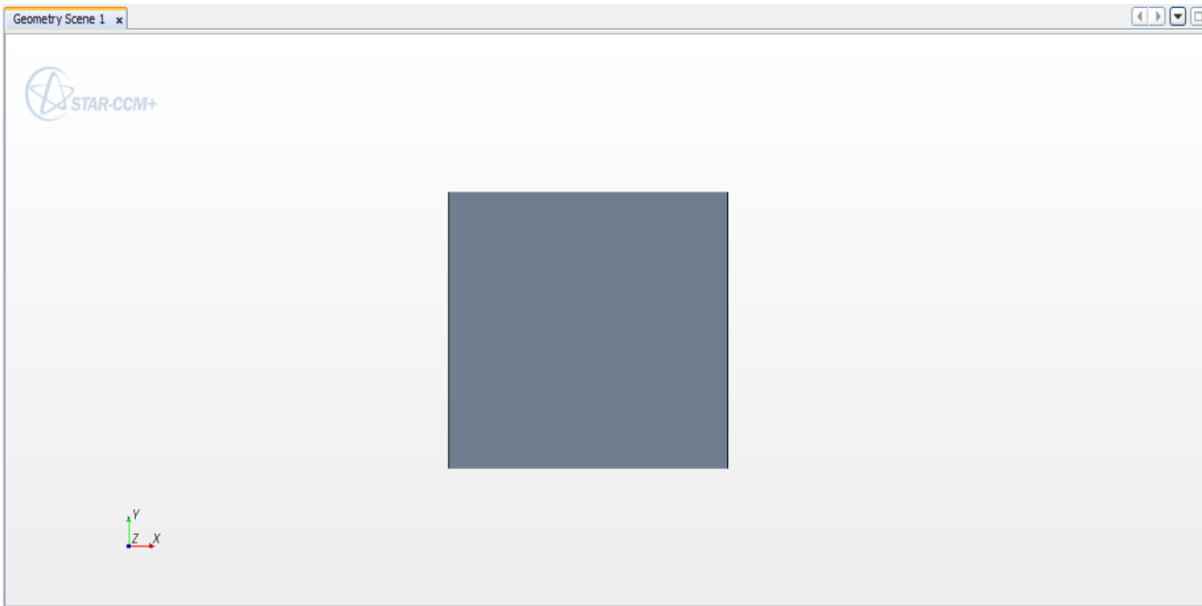


Fig.3.1 GEOMETRY OF THE DESIGN

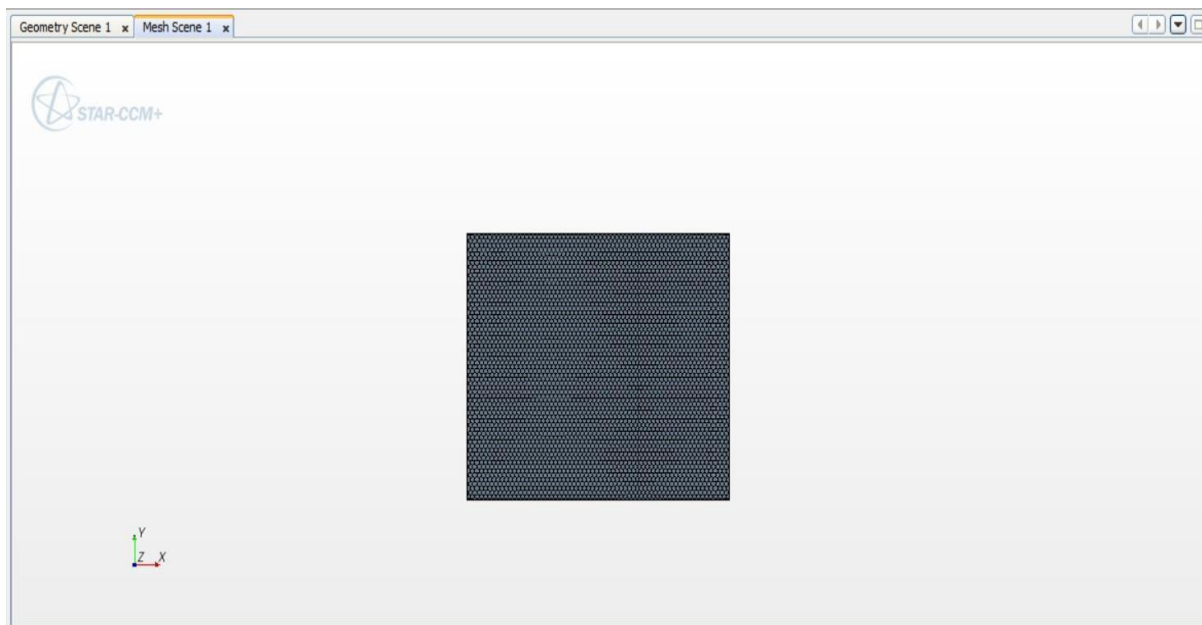


Fig.3.2 MESHING OF THE DESIGN

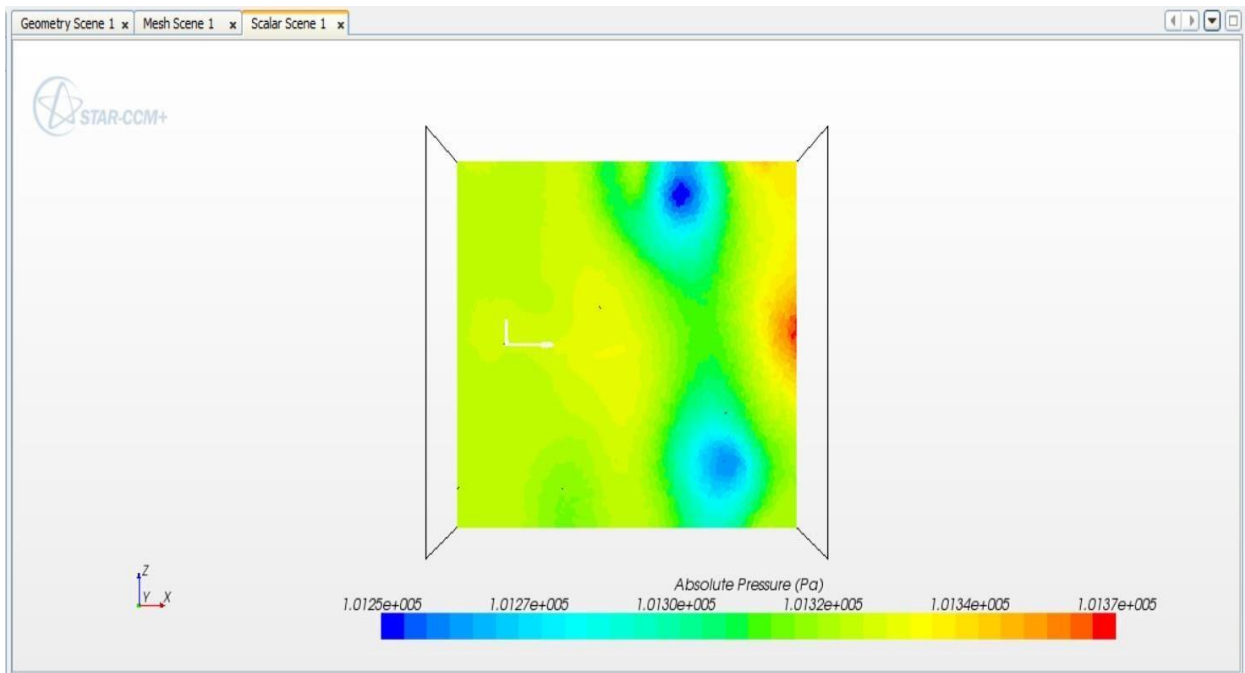


Fig. 3.3 SCALAR OF THE DESIGN

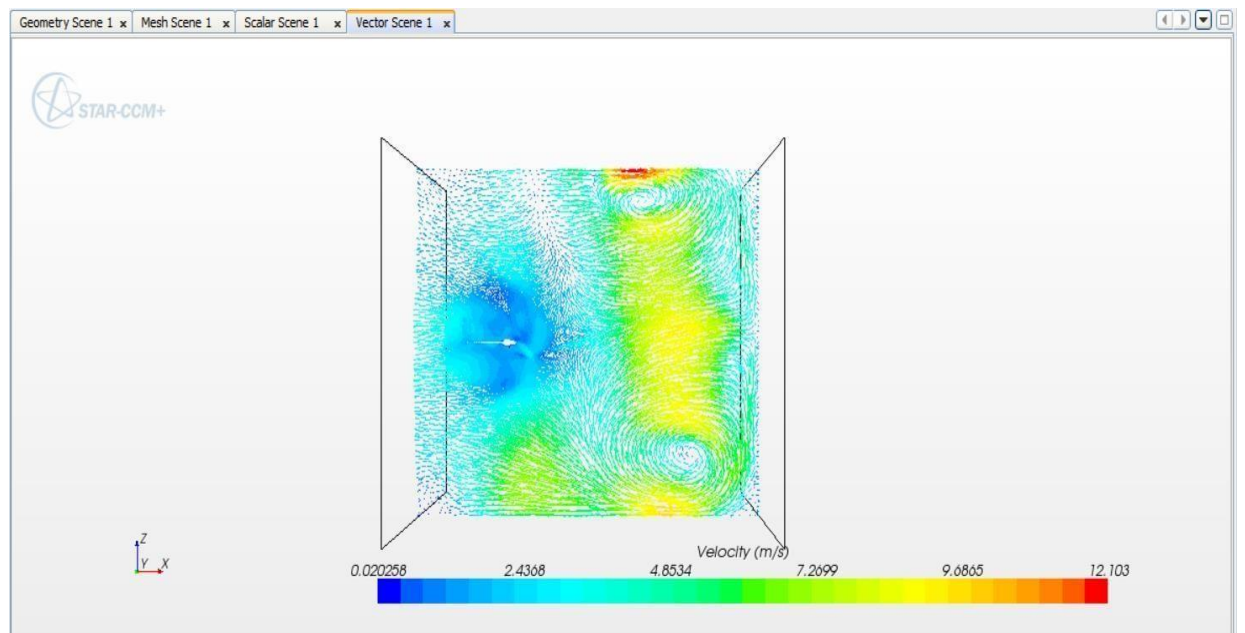


Fig.4.1 VECTOR OF THE DESIGN (VELOCITY)

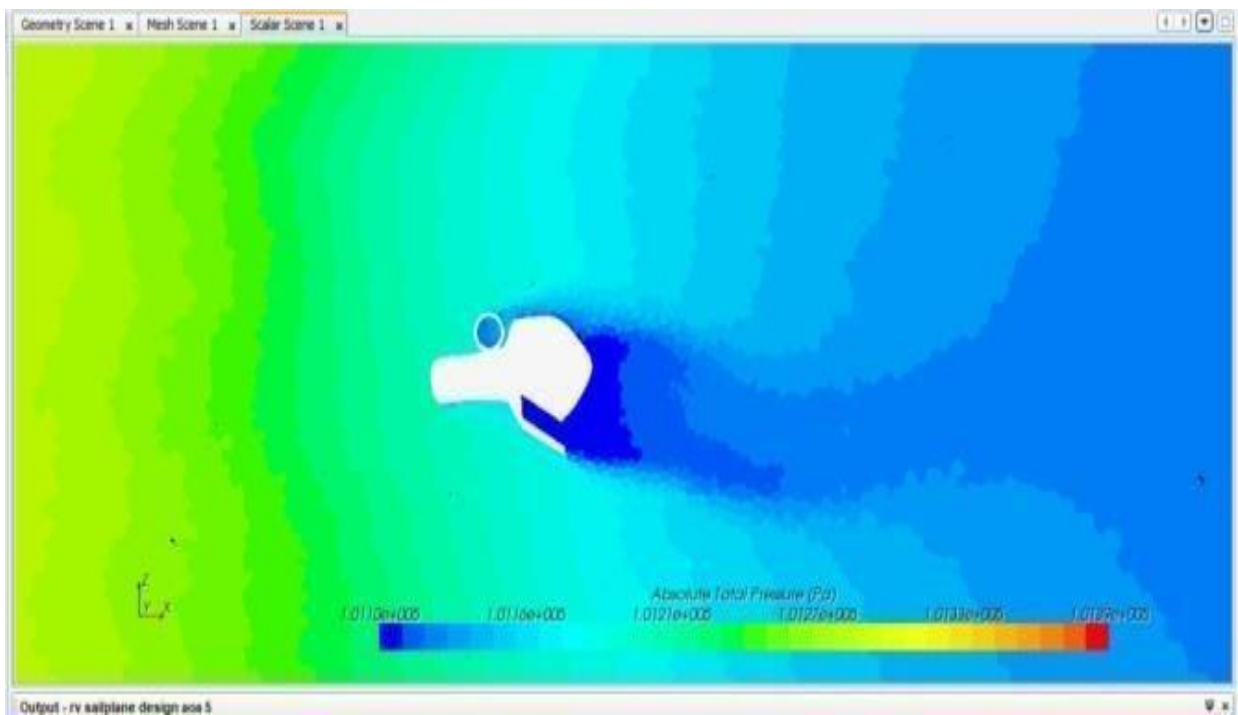


Fig.4.2 VECTOR OF THE DESIGN (ABSOLUTE PRESSURE)

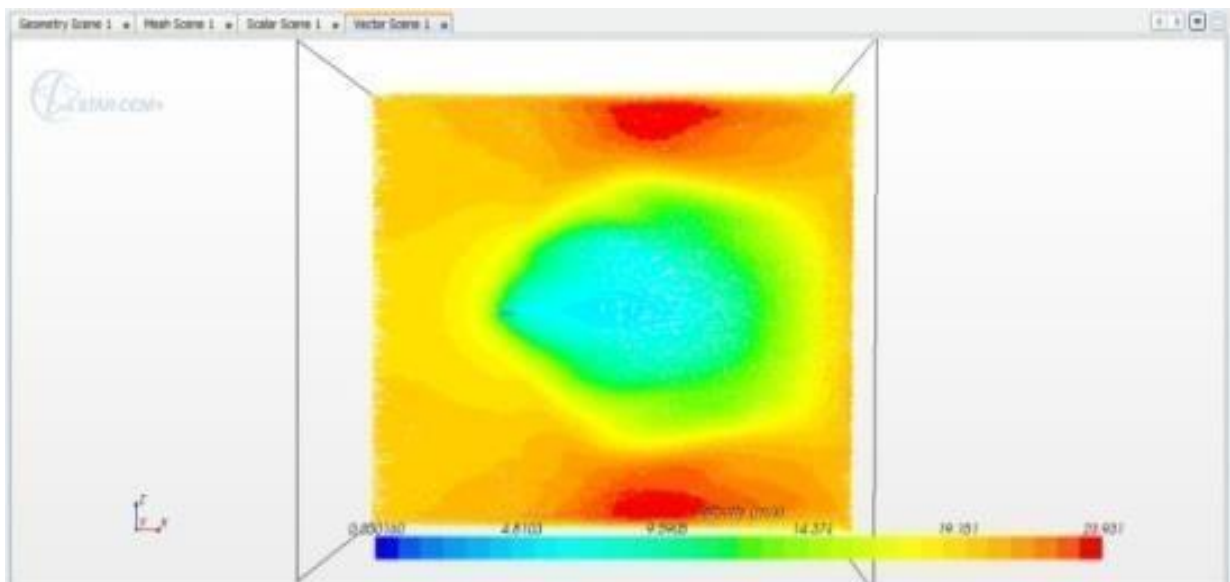


Fig: 4.3 VECTOR OF THE DEISGN (VELOCITY)

CHAPTER NO:6

Experimental testing

6.1 METHODOLOGY: -

The approach for designing a sailplane includes choosing an airfoil based on the typical speed of a moving aeroplane, or the equivalent Reynold 50000. The next step is experimental wind tunnel testing, which includes the collection of test data from which a numerical process incorporating computational fluid dynamics (CFD) is developed. This is used in the creation of the numerical model, which is done with the STAR CCM+ commercial FE code. The collected results are compared to the experimental data, resulting in validation. The validated model is then used to investigate airflow on a sailplane arrangement, after which the design is completed. As illustrated in Figure, the entire process can be summarised in the form of a schematic way.

1. Research and collecting data.
2. Airfoil Selection.
3. Design of the Sailplane modal.
4. Analysis.
5. Fabrication 3D Printing modal.
6. Wind tunnel testing.
7. Compiling the results.

6.2 MATERIALS USED FOR TESTING AND METHODS: -

We have done the experimental testing in subsonic wing tunnel with the 3D printed modal. For the 3D printing modal, we have used the PLA (Polylactic Acid) material. The PLA material is a kind of filament material which is very stronger and stiffer so we can complete the analysis as of our expectation. Low-speed wind tunnels are used for operations at very low Mach number, with speeds in the test section up to 480 km/h (~ 134 m/s, $M = 0.4$) (Barlow, Rae, Pope; 1999). They may be of open-return type (also known as the Eiffel type, see figure), or closed-return flow (also known as the Prandtl type) with air moved by a propulsion system usually consisting of large axial fans that

increase the dynamic pressure to overcome the viscous losses. So, we have set the RPM of the subsonic wind tunnel to 650 RPM (20m/s).

First, the modal is fixed with the help of PVC pipe to change the Angle of Attack (AOA) and 8mm diameter plastic tube are connected to the ports which are in the 3D printed modal in analysis of the wind tunnel. Totally there are six ports in the fuselage and eight ports for wing. These ports are connected to the manometer of the subsonic wind tunnel through the plastic pipes. The plastic tube and the manometer tubes are attached the modal set inside the wind tunnel with the using of PVC pipe and it is also used to change the angle of attack. Subsonic wind tunnel is started, and the RPM is set to 650.the velocity of the atmospheric air of the 20 m/s. The flow of the subsonic wind tunnel is starting from the inlet to honeycomb structure and pass through the test section modal and acting throughout the outlet. The modal is set various angle of attack 0,2,5,8,10,12,15. So the reading is taken from the manometer. The PVC pipes is rolled anti-clockwise direction to change in the experimental setup to change the angle of attack. The ports are taken from the top of the fuselage to the sideways of the model and the top surface of the wing to the same side of the fuselage.so the pipes are connected from there and it's connected to the manometer some of the pipes are liner and its attached correctly to manometer final the experimental analysis completed.



Fig.6.1 ANGLE OF ATTACK 0



Fig.6.2 ANGLE OF ATTACK 5



Fig.6.3 ANGLE OF ATTACK 8



Fig.6.4 ANGLE OF ATTACK 15

6.3 Formulas, Tables and Graphs

Once the wind tunnel testing is completed the calculations of the testing should be carried out. First, the distance of the port in the model is calculated means the x and the y distance are calculated and then is substituted in the formula (MR-4.2)/ (2-4.2) is used. In the above formula the readings of the manometer are entered and the cp values of different angle of attack are calculated. Using these cp values, the cl values are found using the formula $[C_l = (\text{max value upper camber} - \text{min value lower camber}) * (x/C_{\text{max}} - x/C_{\text{min}})]$. The formula is used to calculate the coefficient of lift(C_l) for the different aoa. Then the coefficient of drag(C_d) is found using the formula $[C_d = (\text{max value upper camber} - \text{min value lower camber}) * (y/C_{\text{max}} - y/C_{\text{min}})]$ for the different aoa. The coefficient of moment(C_m) is found using the formula $[C_m = (ac - x/C_{\text{max}}) * (C_l * \cos(\text{AOA}) + C_d * \sin(\text{AOA}))]$ for the different aoa. ac-aerodynamic center - 0.25. because of putting many ports in the sailplane 3d printed model we have calculated the loss coefficient K_{cl} . The formula for the loss coefficient of the ports and the area of the wing and fuselage is divided and then it is applied to the loss coefficient formula $K_{cl} = A_w + A_f - 1$.

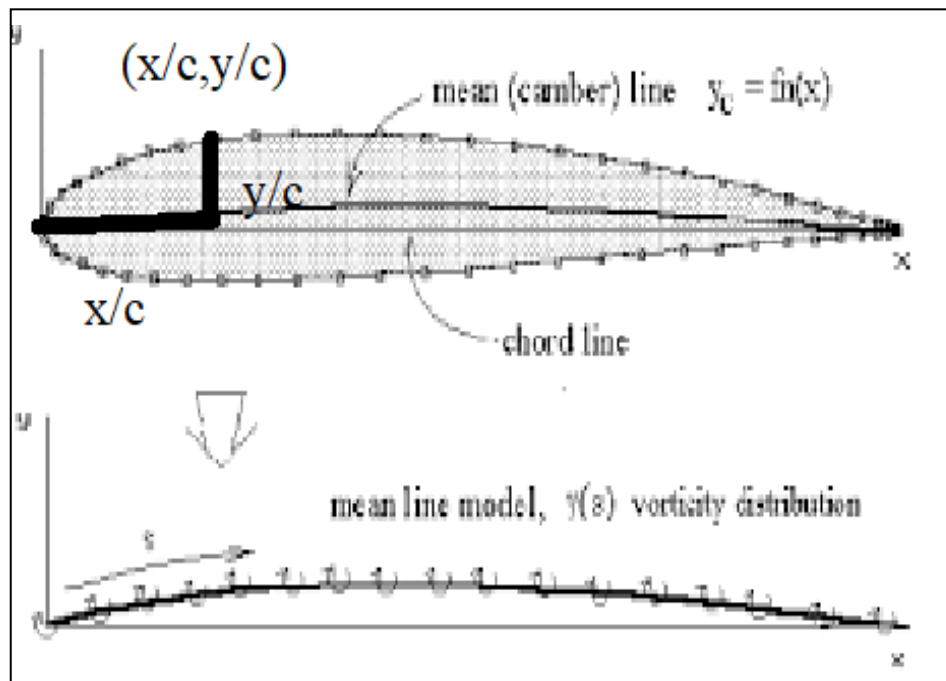
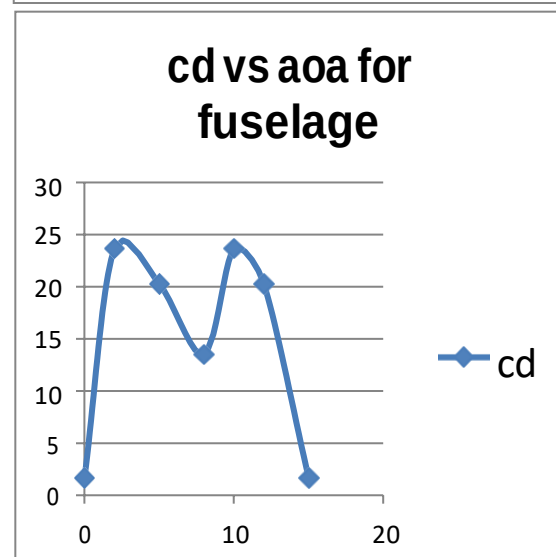
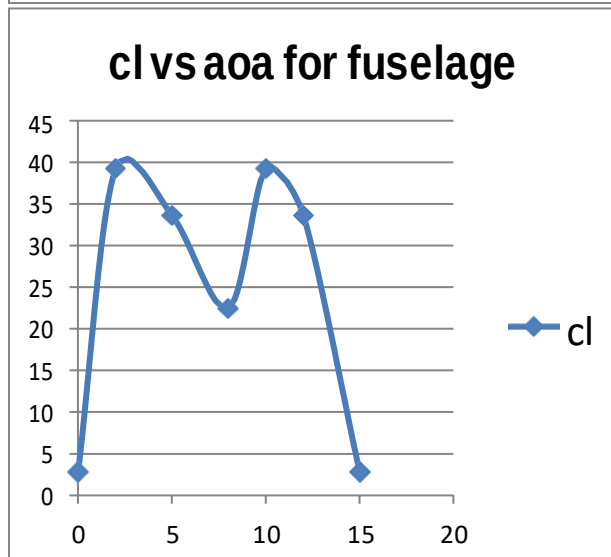
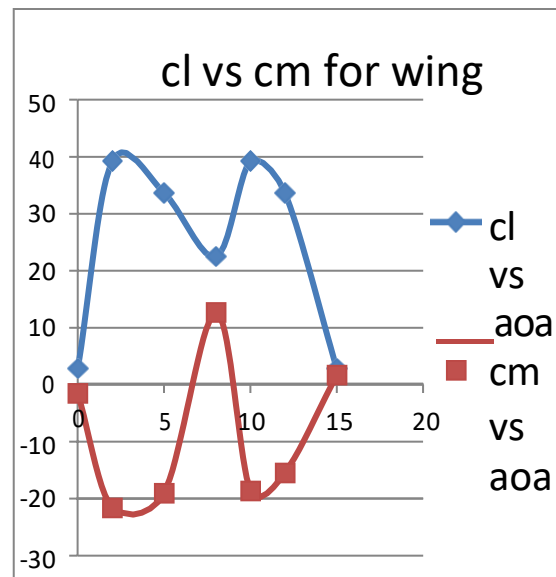
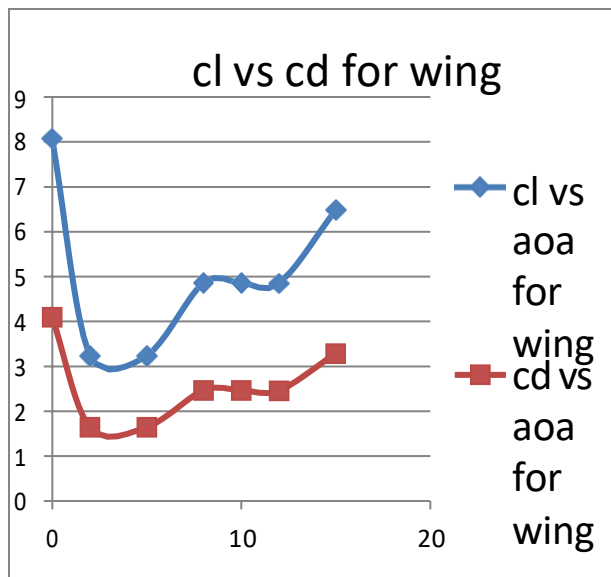
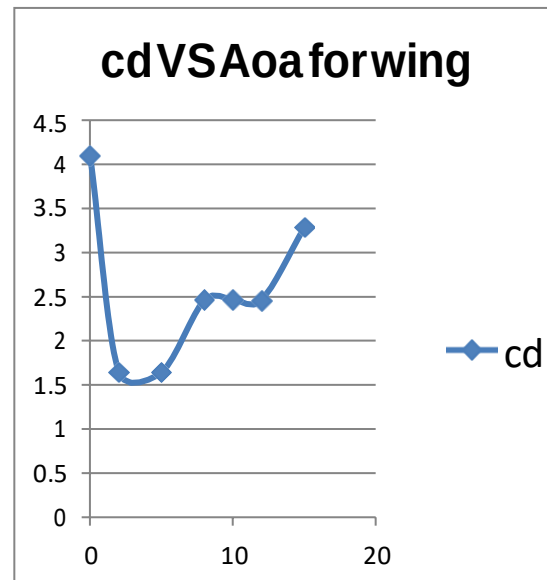
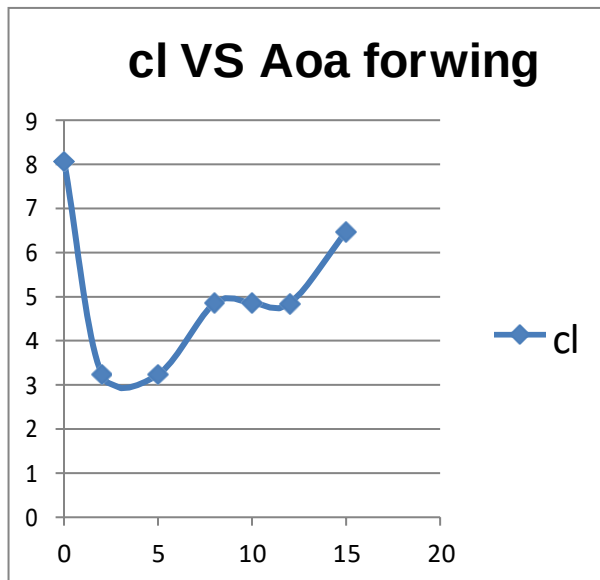


Fig.7 AIRFOIL



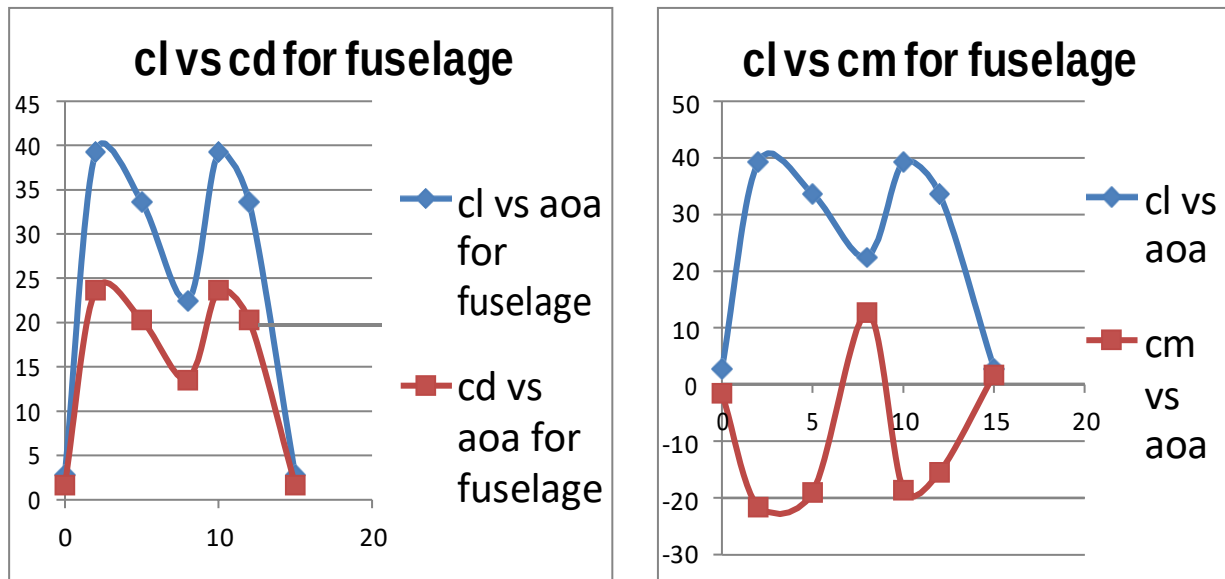


Fig.8.1 EXPERIMENTAL vs ANALYSIS GRAPH

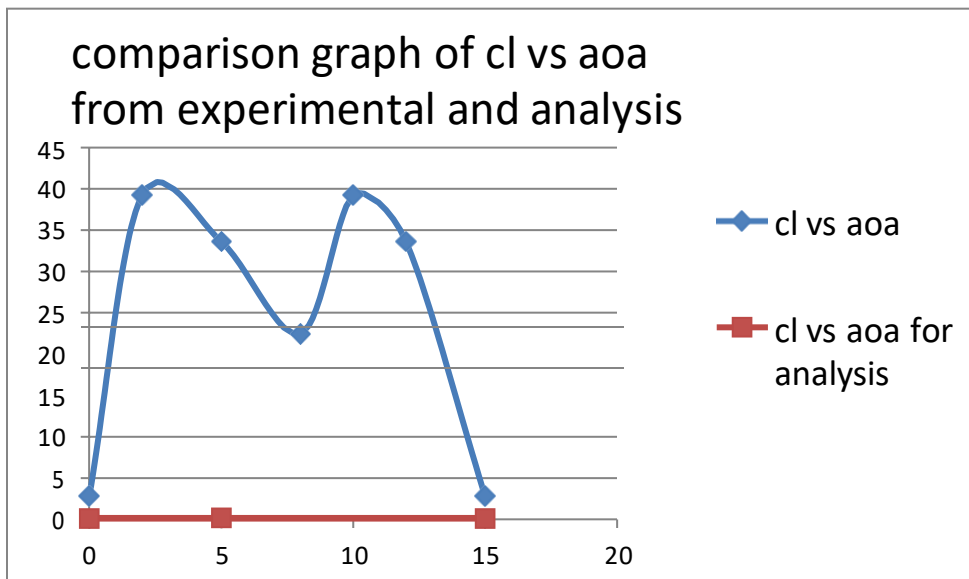


Fig.8.2 Comparison Graph of cl vs aoa from Experimental and Analysis

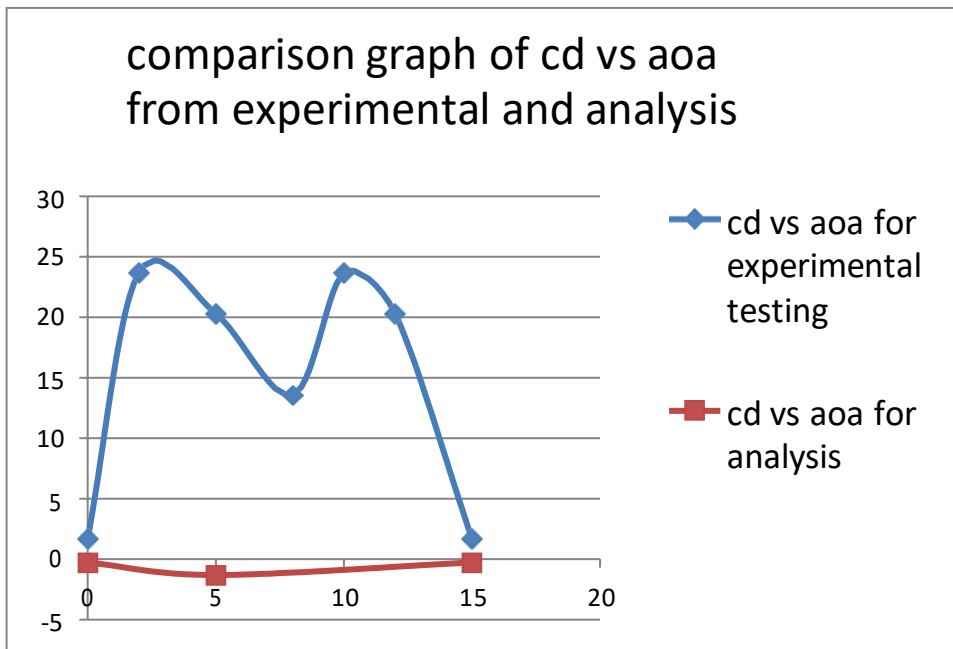


Fig.8.3 Comparison Graph of cd vs aoa From Experimental and Analysis

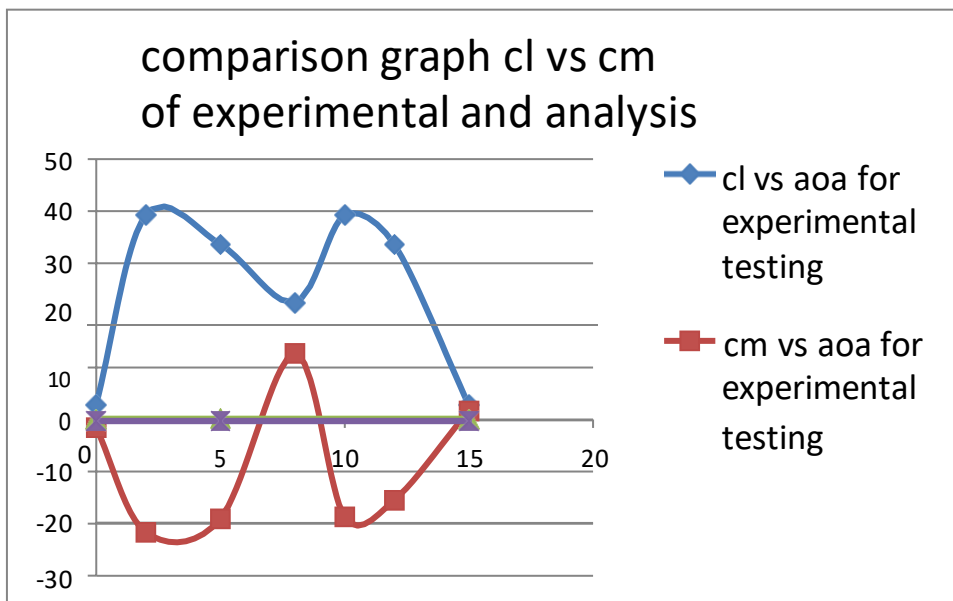


Fig.8.4 Comparison Graph of cl vs cm From Experimental and Analysis

CHAPTER NO:7

Result and Discussion

The optimisation of the sailplane has been done and sandwich panel method is improved to and it is introduced bottom side of the fuselage, this is the modification of the modal using our reference and it has been designed and analysis using CATIA V5 and STAR CCM+ CFD software. This modal has been fabricated using 3D printer with the strong filament PLA it has been tested in subsonic wind tunnel. The result as shown above that CL vs CD that analysis stating from 0 and going above and again come down which is shown as that the correct position changing the AOA was led the modal to maintain longitudinal stability it has been proved in the wind tunnel testing result.

CHAPTER NO:8

CONCLUSION

Thus, the sailplane has been designed and analysed using the software and has been tested to improve the performance of the sailplane. So, in this the performance of the sailplane is improved using the structural sandwich panel method and skid landing gear which help to land the sailplane perfectly. It generates the lift more than general lift as above graph which is maintains the sailplane soaring in the higher rate.

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