

**Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Aeronautical Engineering**

by

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This is to certify that this Project Report is the Bona fide work of **BS GENESIS GODWIN (Reg. No. 38260011)** and **R KARTHIKEYAN (Reg No. 38260018)** who carried out the project entitled "**AERO DYNAMICS ANALYSIS OF MULTI WINGLET IN LIGHT AIRCRAFT**" under our supervision from September 2021 to April 2022.

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DECLARATION

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hereby declare that the Project Report entitled “**AERO DYNAMICS ANALYSIS OF MULTI WINGLET IN LIGHT AIRCRAFT**” done by me under the guidance of **Mr. E. GUNASEKAR** at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Aeronautical and Engineering.

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ABSTRACT

A Winglets are used to improve the aerodynamic efficiency of an aircraft by lowering the formation of an Induced Drag which is caused by the wingtip vortices. Numerical studies have been carried out to investigate the best aerodynamic performance of a subsonic aircraft wing at various cant angles of winglets. This research is based on parallel and serial multi winglets to improve the aerodynamic drag associated with vortices that develop at wingtips as the airplane moves through the air to improve an aircraft's fuel efficiency and cruising range. A baseline and six different multi winglets configurations were tested. The design process is carried out in CATIA. Discretization and the CFD simulation had been carried out through fluent, and the Postprocessing results are obtained using ANSYS.

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

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LIST OF SYMBOLS AND ABBREVIATIONS

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
Cd	Profile drag coefficient
Cdi	Induced drag coefficient
Cd	Total drag coefficient
F	Form factor
Q	Interference factor
Swet	Wetted area of the surface
Sref	Wing area
Rec	Reynolds number of the component
V	Velocity
l	Component characteristics length
u	Kinematic viscosity for that flight condition
e	Ostwald's efficiency factor
AR	Aspect ratio
Cl	Lift coefficient
Λ	Sweep angle
UDF	User Defined Feature

CHAPTER 1

INTRODUCTION

Airplane creators are performing exploration to improve the general airplane proficiency which would be valuable for both airplane producers and the carriers. On account of the airplane plan measure, lessening the general drag at a bargaining level would be one of the difficult measures. Numerous tests have been led to diminish lift-actuated drag. During the later phases of the nineteenth century, F.W. Lan British researcher built up the endplate procedure to decrease the incited drag [1]. -plane hypothesis by Prandtl in 1910 was created to decide the incited drag and furthermore this hypothesis could decide the incited drag both locally and around the world. s hypothesis has been utilized to decide the impacts of actuated drag by numerous analysts. Afterward, the idea of initiated drag and the strategy to decide the initiated haul by conformal planning and electrical potential similarity technique was created. As per Cone, the initiated drag factor could be articulated by the viable viewpoint proportion which could be dictated by the electrical similarity of the lifting framework. Also, numerous wingtip gadgets and tip augmentations were created from the start of 19th century and investigates are proceeding to date for initiated drag decrease. The development furthermore, late improvements in winglet innovation will be talked about in a later area. Additionally, the fundamental motivation behind winglets from the point of view of both airplane producers and administrators will be examined.

1.1 BACKGROUND

Winglets are vertical augmentations of wingtips that improve an airplane's eco-friendliness and cruising range. Planned as little winglets lessen the streamlined drag related with vortices that create at the wingtips as the plane travels through the air. By diminishing wingtip drag, fuel utilization goes down and range is broadened.

Airplane, all things considered, and estimates are flying with winglets - from single-seat hang lightweight flyers and ultralights to worldwide gigantic planes. Some aircraft are planned and produced with smooth improved winglets that mix easily into the

external wing segments. Extra winglets are likewise hand crafted for some sorts of airplane.

The idea of winglets started with a British aerodynamicist in the last part of the 1800s, however the thought stayed on the planning phase until revived in the mid 1970s by Richard Whitcomb when the cost of flight fuel began upward. Whitcomb, a prominent aeronautical architect at the NASA Langley Research refined the winglet idea with air stream tests and PC contemplations. He at that point anticipated that transport-size airplane with winglets would acknowledge improved cruising efficiencies of somewhere in the range of 6% and 9%. A winglet flight test program at the NASA Dryden Flight Research Centre in 1979-80 approved Whitcomb's examination when the test airplane - a military form of the Boeing 707 jetliner - recorded an expanded fuel mileage pace of 6.5%.

1.1.1 BENEFITS

Since the 1970s, when the cost of flying fuel started spiralling upward, carriers and airplane producers have taken a gander at numerous approaches to improve the working effectiveness of their airplane. Winglets have gotten one of the business' most obvious fuel-saving advancements and their utilization keeps on extending.

Winglets increment an airplane's working effectiveness by diminishing what is called instigated haul at the tips of the wings. An airplane's wing is moulded to create negative tension on the upper surface and positive tension on the lower surface as the airplane pushes ahead. This inconsistent pressing factor makes lift across the upper surface and the airplane can depart the ground and fly.

Inconsistent pressing factor, nonetheless, likewise causes air at each wingtip to stream outward along the lower surface, around the tip, and inboard along the upper surface delivering a tornado of air called a wingtip vortex. The impact of these vortices is expanded drag and decreased lift that outcomes in less flight productivity and higher fuel costs.

Winglets, which are air foils working very much like a boat attaching upwind, produce a forward push inside the flow field of the vortices and lessen their solidarity.

More vulnerable vortices mean less drag at the wingtips and lift is re-established. Improved wing effectiveness means more payload, diminished fuel utilization, and a more drawn-out cruising range that can permit an air transporter to extend courses and objections.

To deliver however much forward push as could be expected, the winglet's air foil is planned with similar consideration as the air foil of the actual wings. Execution upgrades produced by winglets, nonetheless, rely upon elements like the essential plan of the airplane, motor proficiency, and even the climate wherein an airplane is working.

The shapes and sizes of winglets, and the points at which they are mounted as for the primary wings, contrast between the numerous sorts and sizes of airplane delivered yet they all address improved proficiency. All through the avionics business, winglets are liable for expanded mileage paces of as much as 7%.

Airplane producers and creators of extra winglets have likewise announced improved cruising speeds, time-to-climb rates, and higher working heights.

The utilization of winglets all through the flying business in the U.S. also, abroad is continually developing. Winglets currently show up on feeble hang lightweight flyers taking off above mountain edges and from shoreline precipices. Sailplane developers around the globe have included mixed winglets to their plans and the smooth, effortless lightweight flyers are quietly taking off farther than any time in recent memory. Corporate-size Learner's were the principal business airplane to utilize winglets. Presently, a very long while later, winglets are consolidated into the plans of numerous other business planes like Gulfstreams and the Global Express: another airplane worked by Lear's parent organization, Bombardier.

Retrofitting winglets to existing business jets is likewise a quickly developing business sector inside the flying business itself. Numerous winglet promoting firms report their items help increment airplane move rates and lower approach and departure speeds.

1.1.2 CATIA

Airplane configuration is a perplexing cycle that has numerous stages wherein Catia assumes a huge part. Numerous airplane makers like Boeing, Dassault, and Airbus have been receiving Catia programming devices like Fusion 360 to limit the lead time and to evade delayed span in the plan interaction. Catia joined with Knowledge-

based designing (KBE) pointed toward diminishing the time taken for the plan interaction if there should arise an occurrence of redundancy. Studies have been done on creating defined Catia models centring to advance the given model with less length of time. D administrator and K administrator were the two methodologies created with CAE apparatuses for making monotonous cycles. KP has been actualized in Dassault frameworks programming CATIA V5 R1. One of the fundamental weaknesses in VB content for dynamic launch of the models is longer time utilization for scripting. Studies uncovered that mechanization for making models and examples powerfully were done dependent on Information Pattern content where the time burned-through for design creation and scripting were a lot lesser than the VB approach.

CHAPTER 2

2.0) LITERATURE REVIEW

2.1.1 HISTORY OF WINGLETS

Endplate theory was the primary to propose a wingtip device and was proprietary by Fredrick W. Lanchester, British Aerodynamicist in 1897. sadly, his theory couldn't scale back the overall drag of craft despite reducing the induced drag. the rise within the viscous drag during cruise conditions outruns the reduction in induced drag. In Gregorian calendar month 1976, Dra Whitcomb made analysis at independent agency Langley centre and developed the construct of winglet technology. per Whitcomb, a winglet may well be delineated because the little wing-like vertical structures that extend from the wingtip, aiming at reduction in induced drag when put next to different wingtip devices or extensions. He additionally claimed in his analysis that the winglet shows a two hundredth reduction in induced drag when put next to tip extension and additionally improved lift-to-drag quantitative relation. In 1994 Aviation Partners Inc. (API) built up a high-level plan of winglets called mixed winglets. Louis B. Glatzer from Seattle has the patent for mixed winglets and the goal of the winglet is to decrease the impedance haul because of sharp edges as found in Whitcomb's winglet. Additionally, Glatzer has the patent for the development of the spiroid-tipped wing in April 7, 1992. Afterward, the "wing network" idea was created by La Roche from Switzerland in 1996 also, got the patent for his innovation. The principal motivation behind all the above developments was to decline the strength of the wake vortex and to decrease instigated drag.

2.1.2 TYPES OF WINGLETS AND WINGTIP DEVICES

After the innovation of the winglet by Whitcomb, numerous kinds of winglets and tip gadgets were created via airplane architects. A portion of the developments of winglets by the separate airplane producer are examined in the accompanying segment.

2.1.3 single Winglets

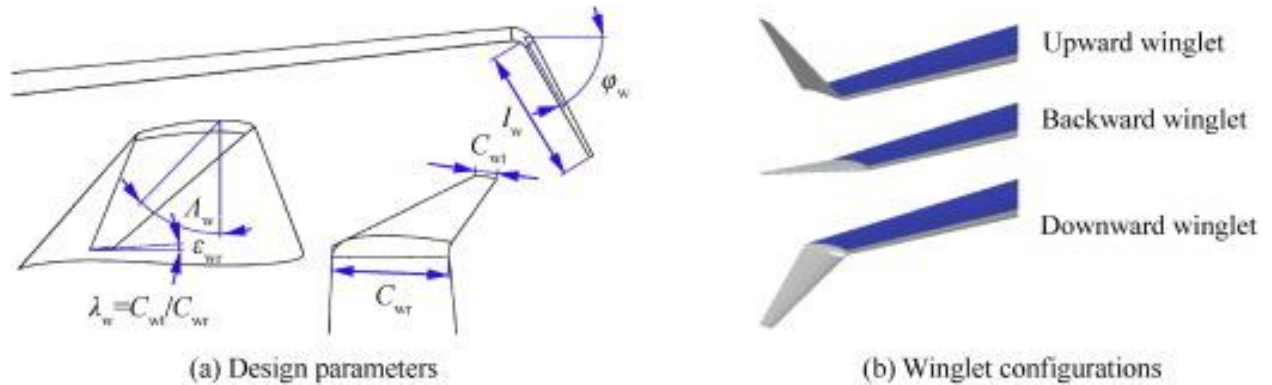
single winglet was created by Grater from Seattle in 1994. The special plan in this winglet is no sharp edge found at the wing/winglet convergence and followed by smooth bend. Flying Partners Inc. (Programming interface) and Boeing Company made joint effort in 1999 for the plan of cutting-edge mixed winglets 1999. Mike Stowell, Executive VP of APB referenced about the impedance drag, a streamlined marvel caused due the crossing point of lifting surfaces, subsequently the winglet configuration was created to defeat the impedance drag framed at the intersection of wing and winglet. The winglets were retrofitted in Boeing business jets and furthermore in B737. Presently these flights have their administrations in American aircrafts (Southwest carriers) and furthermore in European aircrafts (Ryanair).



2.1.4 parallel Winglets

The parallel wing technology was invented and patented in 1992. One end of the wingtip was positioned in different angle connected to the forward portion of the wing tip and three different angle winglet that ends at the wing tip's aft portion. As a result, when viewed from the front, it appears in decent form factor.

The parallel winglet was developed to minimise induced drag as well as the noise effects associated with it.

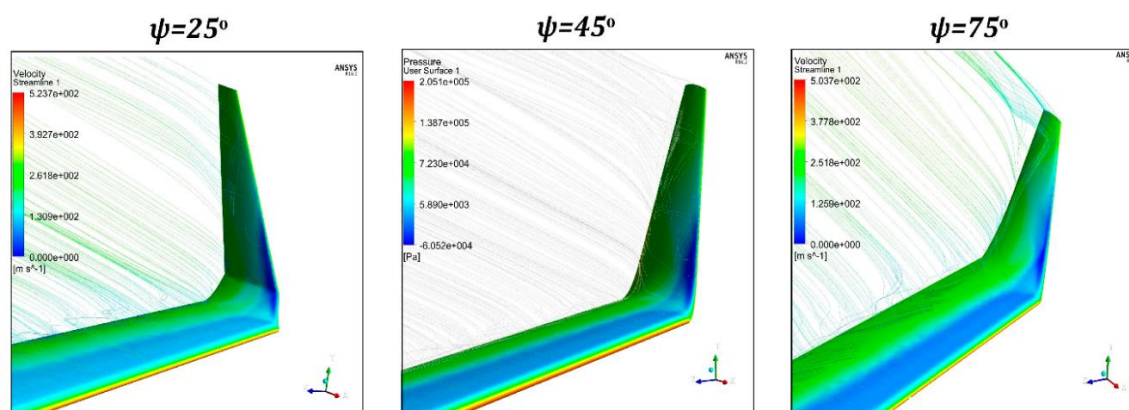


Wing-Grid as Wing Tip

Wing lattice calculation is characterized by at least two wing like surfaces running corresponding to one another from the finish of wing area which shapes the matrix. La Roche from Switzerland held the patent for this development since October, 1998. Rather than whole wing with no tip gadgets, wing lattice at halfway range could be supplanted. La Roche asserted that wing framework could give a lot of decrease in prompted drag when contrasted with wing range augmentation.

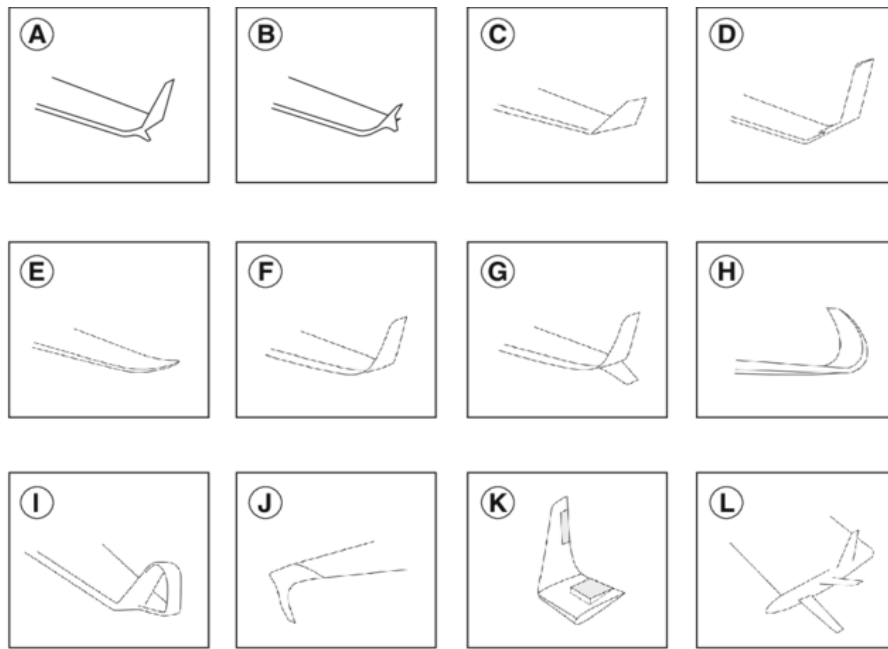
2.1.5 serial Winglets

Serial winglet from Boeing Company was planned by Herrick and got the patent in 2000. The serial tip is joined with the principal wingtip with higher point of clear than the primary wing. Boeing 777 long-range jets have been planned with serial winglet.



2.1.6 Different Types of Winglets

- A. WHITECOMB WINGLET.
- B. TIP FENCE.
- C. CANTED WINGLET.
- D. VORTEX DIFFUSER.
- E. SINGLE WINGLET.
- F. PARALLEL WINGLET.
- G. BLENDED SPLIT
- H. SHARKLET.
- I. SERIAL WINGLET
- J. DOWNWARD CANTED WINGLET
- K. ACTIVE WINGLETS
- L. TIP SAIL



different types of tip devices

The incited drag and the absolute drag are determined for various speeds. In view of the estimation, the level of incited haul in all out drag was determined. The outcomes are plotted against the speed which could be found in the figure 20. From the diagram appeared in figure 20, the commitment of the instigated haul in complete drag is discovered to be over 80% at the point when the speed is given around 60m/s. As the speed expands the level of actuated drag is seen to be decline and about under 20% at the speed, 250 m/s. The outcome shows that the impact of instigated drag would be a lot higher during the take-off condition and lesser impact during voyage condition.

2.1.7 different types of tip devices

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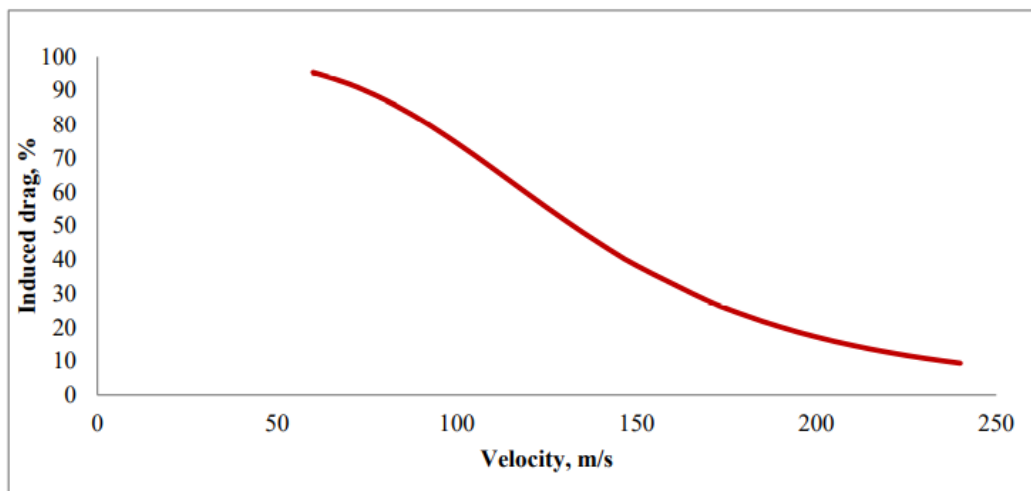


Figure *Induced drag percentage of the aircraft wing against the velocity, m/s*

2.1.8 Parameterized Winglet models

KP has been applied to the winglet layouts for the mechanization cycle and the outcomes have been talked about in this segment. As the information boundary has been given as "no winglet" in the worldwide boundary set, there is no tip gadget connected to the end part of fundamental wing as demonstrated in figure

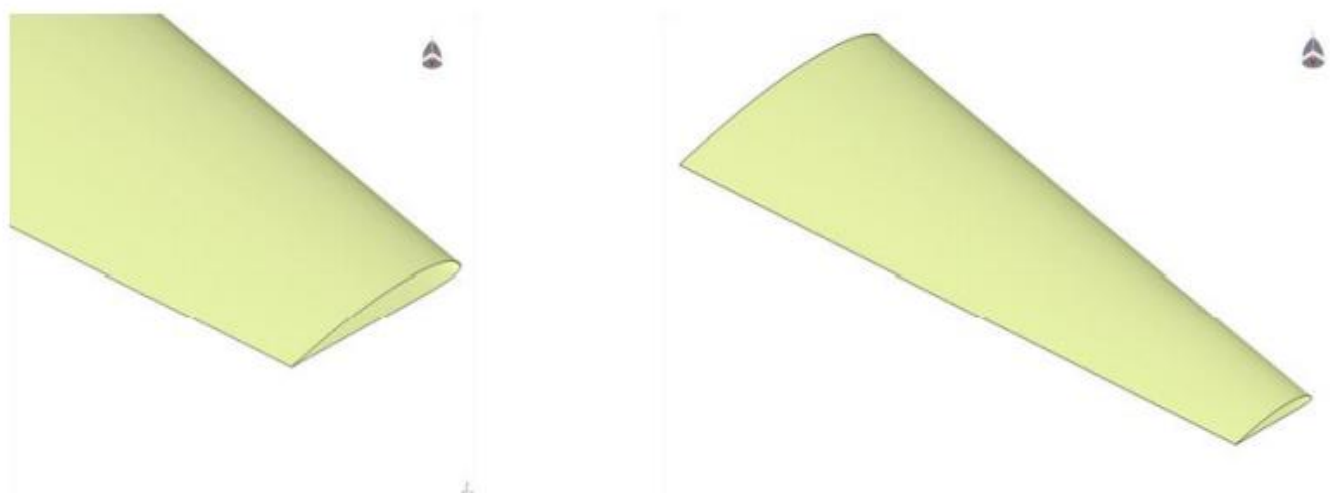
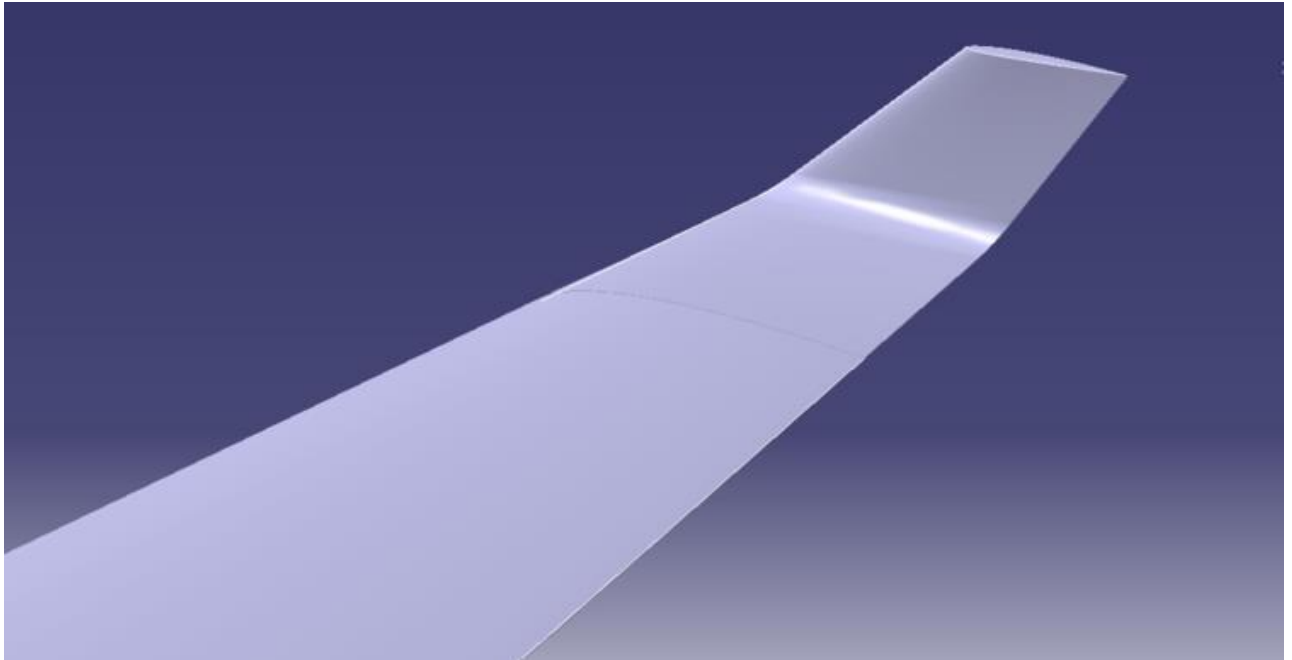


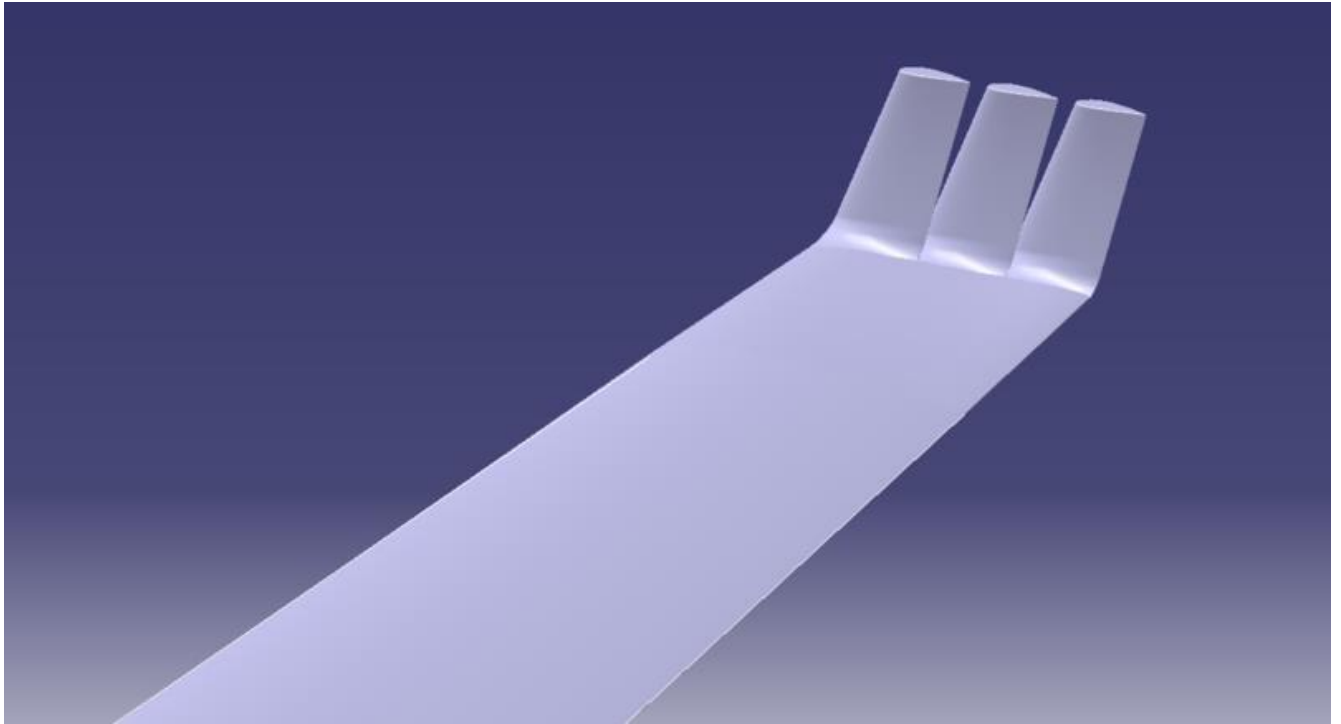
Figure *No winglets or wingtip devices at end section*

Presently, the info has changed to "mixed" thus the surface model of mixed base is started up. the other shows the mixed model without a board could be another choice for the client.



3 - single Winglet: a) single base; the base Panels placed upon base

After changing the kind of winglet boundary to wing wall, the skeleton model is produced. Figure 29a addresses that flat boards have been started up. At the point when the quantity of fence board vertical for upper segment 1 was picked to be 2 green boards are launched as appeared in figure in any case, for the lower board to be started up, the quantity of upper boards ought to be more prominent than 1 as lower board relies upon the upper board's



4 - Figure serial winglets with three panels

As referenced in mechanization area, when the kind of winglet becomes wing framework, just the framework root is started up at that point the quantity of boards that ought to be put on the framework root is given in the worldwide boundary. In figure, two boards are started up where the distance between each board was chosen by position boundary which was examined in 27 prior segments. Moreover, the breadth point and dihedral point is additionally changed which could be found in the accompanying figure. At last, the tip devices that are started up after choosing the kind of winglets are appeared in following figure.

2.1.9 ADVANTAGES CLAIMED ON WINGLETS AND TIP DEVICES

if the client should be put upon the base, the quantity of boards required ought to be given in the info field "no of mix board". The started up model is appeared in figure 26b as there are two boards set on the base segment. On the other hand figure shows the mixed model without a board could be another choice for the client. winglets would diminish the actuated drag more than tip expansion and will be at its best when it is almost vertical. Later in 1980, R.T Jones made an exploration in winglets to decide its impact over the actuated drag utilizing Trefftz-plane hypothesis and presumed that the vertical length of the winglet ought to be twice than the length of level augmentation to have its benefit over tip expansion. Flight Partners Boeing declared that their APB mixed winglet has saved in excess of 2 billion gallons of fuel in 2010. APB likewise added that the winglets could save 5 billion gallons of fuel by 2014 which additionally addresses the absolute decrease in fossil fuel by product. Surely, APB mixed winglet on B737 showed expanded in scope of around 5-7% because of by and large decrease in drag. In the event of spiroid tipped wing, API has made a flight test on Gulfstream II in 1993 and they accomplished over 10% of eco-friendliness during the journey condition. serial winglet is a remarkable

plan for Boeing B777 family and it has improved the airplane's presentation by lessening the take-off field length, improved eco-friendliness and great ascension execution. Parallel winglet could give 2 % decrease in fuel consume which is repaid by 1.3 million of fuel saving each year and 3.9 million of carbon-di-oxide discharge per year³. Sharklets is the new development from the Airbus Company for their A320 family. They guaranteed that sharklets would lessen fuel wreck to 3.4% and this compares to 700 tons of fossil fuel by product per airplane in a year. Airbus additionally added that A320 could take off with more weight because of the exhibition of sharklets⁴. The exploration made with spiroid tipped wing demonstrates that it would scatter the vortex impacts with in limited ability to focus time and along these lines the ideal opportunity for take-off and setting down between the airplane would be decreased.

Boeing Series advantages after using winglet (http://www.b737.org.uk/winglets.htm)		
Series	Range before	Range(Winglets)
B737-700	3250	3634
B737-800	2930	3060
B737-900	2670	2725

The above table shows that there was an increase in range when serial winglets were retrofitted.

Summarizing the advantages of winglets,

- Reduced induced drag
- Improved fuel efficiency
- Increased range and more payload
- Reduced noise effects due to vortex effects
- Reduced the amount of carbon emissions
- Helpful in air traffic control

2.2.0 INDUCED DRAG PHENOMENA

In Aerodynamics, the four primary powers which follow up on airplane during the flight are Lift, Drag, Thrust and Weight. Drag is perhaps the most basic wonders among all and is the restricting power of airplane's forward movement. It very well may be grouped momentarily in to parasite drag (not because of lift) and lift initiated drag. In a common vehicle airplane, frictional drag and prompted drag together offers over 80% of the all-out haul as addressed in figure 8, yet different types of drag couldn't be barred surely.

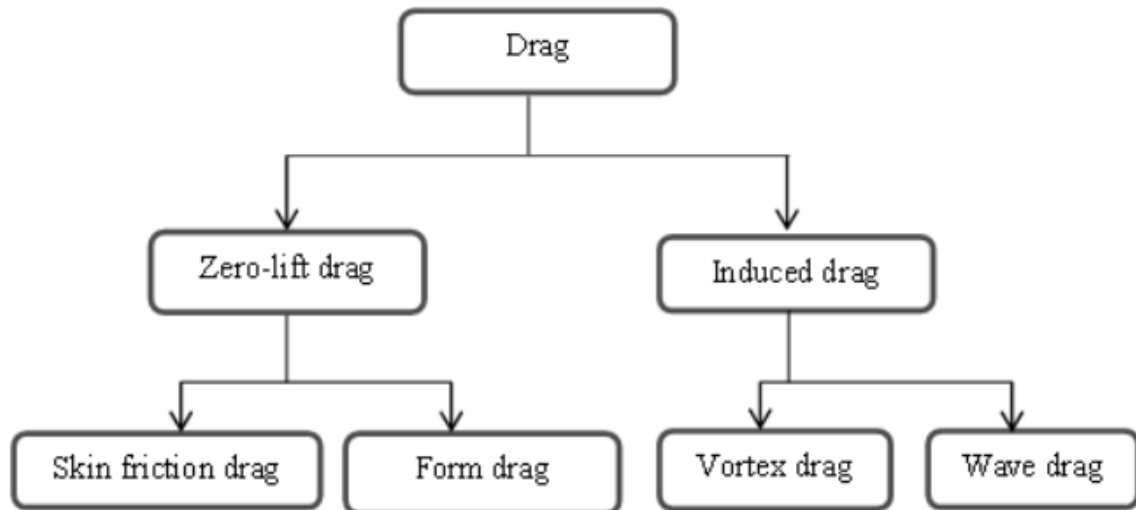


Fig different forms of drag

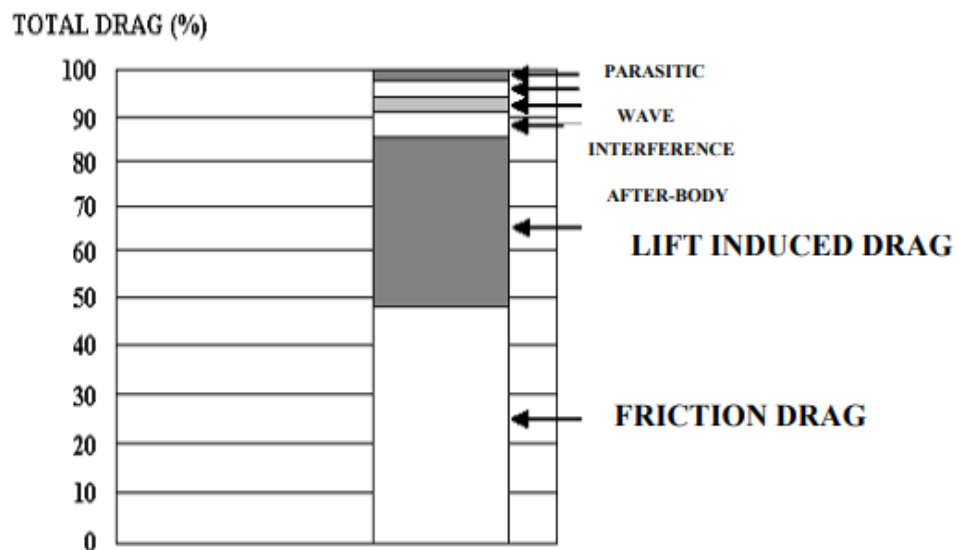


Fig distribution of drag components

Actuated drag produces active energy which will cause the descending movement opposite to the wind current. This descending power could be perceived as the lift vector and this part is viewed as the instigated drag. Prompted drag contrasts from different types of drag through a wonder of changing over the scattered active energy into heat slowly. Vortex wake is a novel component of initiated drag. Mixture Mclean has proposed the misinterpretations of the actuated drag and the vortex wake delivered by the wing. Regularly the vortex wake is created from the stream design because of the distinction in speeds at upper and lower surface of an air

From the figure 9, it is shown that the speeds at the down surface move towards the upper surface and consequently it makes a roundabout stream design. This stream design is liable for the vortex sheet that created from the whole range of the wing.

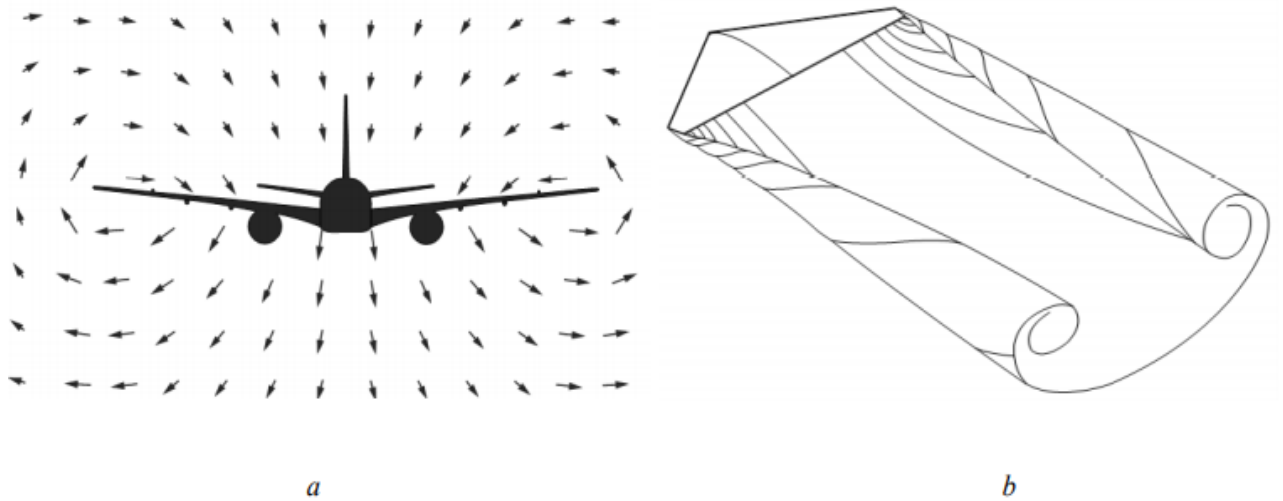


Fig (a)flow pattern of the velocity (b)vortex sheet from trailing edge

As referenced by Douglas, the basic misconception with the vortex sheet was that, the prompted drag caused because of the proposal's vortices delivered from the speed stream design. Moreover, lessening the strength of vortex couldn't significantly affect the initiated drag. Examination has been directed to decrease the initiate drag and various techniques have been created to figure this lift incited drag. Utilizing one of the proposed techniques, actuated drag for a business stream transport airplane is determined and will be examined in forthcoming segment.

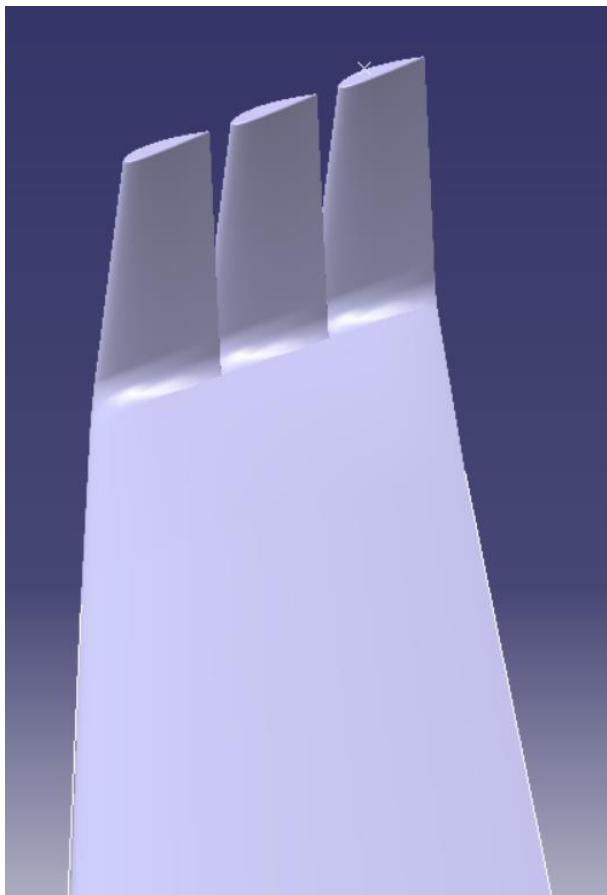
CHAPTER 3.

AIM AND SCOPE

3.1.1 AIM

The objective of this study is to develop an automated parametric model for different types of winglets and wingtip devices using the software CATIA V5 r1. Knowledge Pattern approach is used for the automation process. The main tasks of this thesis work are: To find the induced drag contribution in an aircraft by conceptual approach. The fundamental part of the model is to diminish the time taken by the creator during the plan measure. The created nonexclusive model can switch between various sorts of wingtip gadgets according to the client's necessities with accessible boundaries. The model made will be valuable in airplane wing configuration as well as in propeller plan for wind turbines.

SERIAL WINGLET IMAGE OF CATIA DESIGN



3.1.2 SCOPE

The market has been sectioned in significant districts to comprehend the worldwide turn of events and request examples of this market. For aviation winglets market, the fragments by area are North America, Asia Pacific, Western Europe, Eastern Europe, Middle East, and Rest of the World. During the conjecture time frame, North America, Asia Pacific and Western Europe are relied upon to be significant districts on the aviation winglets market. North America and Western Europe have been predominant parts in this market with the presence of significant organizations which have a solid framework to support aviation and safeguard area. Furthermore, a portion of the significant nations like the US, France, UK, and Canada has been worldwide exporters of aviation and protection advancements because of set up research and improvement focus, and others. Likewise, a portion of the significant organizations working in aviation winglets market are settled in these locales. The Asia Pacific area is assessed to enrol quickest developing aviation winglets market since a portion of the significant economies like China, India, and South Korea are available in the locale. In ongoing many years, these nations have seen solid government spending on safeguard framework, just as advancing air transport and space research. During the conjecture time frame, the Middle East locale is assessed to be a possible area for aviation winglets market in the aviation and protection area. It is assessed that Eastern Europe will have stable interest during the gauge time frame. Likewise, the remainder of the world is relied upon to be a developing business sector with expanding request.

CHAPTER 4.

4.0) MATERIALS AND EXPERIMENTAL METHOD

4.1.1 METHODOLOGY

STEP 1 INITIALLY WE TOOK REFERENCE WINGLET DIMENSIONS

STEP2 CREATING A 3-D MODEL OF TWO TYPES OF MULTI WINGLETS USING CATIA SOFTWARE

STEP3 COVERT 3-D MODEL INTO STEP FILE

STEP4 IMPORT STEP FILE INTO ANSWERS BY FLUENT SOFTWARE

STEP5 BOUNDARY CREATION FOR CFD SIMULATION

STEP6 - SOLVING THE CFD MODEL

STEP7: -ANALYSIS THE RESULT TO IMPROVE AERODYNAMICS PERFORMANCE

STEP8: - SELECT THE GOOD RESULT MODEL

4.1.2 Method for Induced Drag Calculation

$$C_d = C_{d0} + C_{di} \quad [1]$$

$$C_{d0} = C_f FQ[S_{wet}/S_{ref}] \quad [2]$$

$$C_f = [0.455]/[(\log Re_c)^{2.58} (1 + 0.144Mn^2)^{0.65}] \quad [3]$$

$$Re_c = (Vl)/\nu \quad [4]$$

$$F = (F^* - 1) \cos^2 \Lambda_{0.5c} + 1 \quad [5]$$

$$F^* = 1 + 3.3 (t/c) - 0.008 (t/c)^2 + 27 (t/c)^3 \quad [6]$$

Where=

C_f -Skin friction drag coefficient

F-Form factor

Q-Interference factor

S_{wet} -Wetted area of the surface

S_{ref} -Wing area

Re_c = Reynolds number of the component

V = Velocity

l = component characteristics length

u = kinematic viscosity for that flight condition

$$C_{di} = KC_L^2 \quad [7]$$

$$K = 1/\pi e AR \quad [8]$$

e - Span efficiency or Oswald's efficiency factor

AR – Aspect ratio

C_l – Lift coefficient,

$$e = \{0.47 + (1/\sqrt{AR})\} * (\cos\Lambda^{0.1}) \quad [9]$$

Λ – Sweep angle.

Lift-induced drag because of vortex depends on the lift coefficient of the wing, perspective proportion and the range effectiveness factor. The profile drag and initiated drag are determined from the abovementioned recipe (from condition 1-9) with the quality's dependent on the airplane's detail table (Appendix 1). The all out drag is determined for various heights and furthermore for various speeds, beginning from slow down speed to journey speed. The complete drag determined will be utilized for deciding the extra drop weight for a similar take-off distance.

4.1.3. CATIA METHODOLOGY

CATIA V5 R1 apparatus is utilized to build up the formats of various winglets and tip gadgets. Each winglet has been characterized by a client highlight where the client could pick between the sorts of winglet and alter the boundaries related with particular winglet model.

A nitty gritty portrayal of the winglet layouts is talked about in the accompanying segment. The coordinates are provided for the development of the NACA 2412 serial winglet purpose for producing the low drag with higher lift

NACA 2412 air foil coordinates are generated in CATIA by using view macros in Microsoft excel according to the geometry of the blade is created to complete the model.

The following parameters are used to design the Vertical axis wind turbine

Air foil used : NACA 2412

Blade length : 0.660 m

Rotor diameter: 0.526 m

Rotor radius : 0.263 m

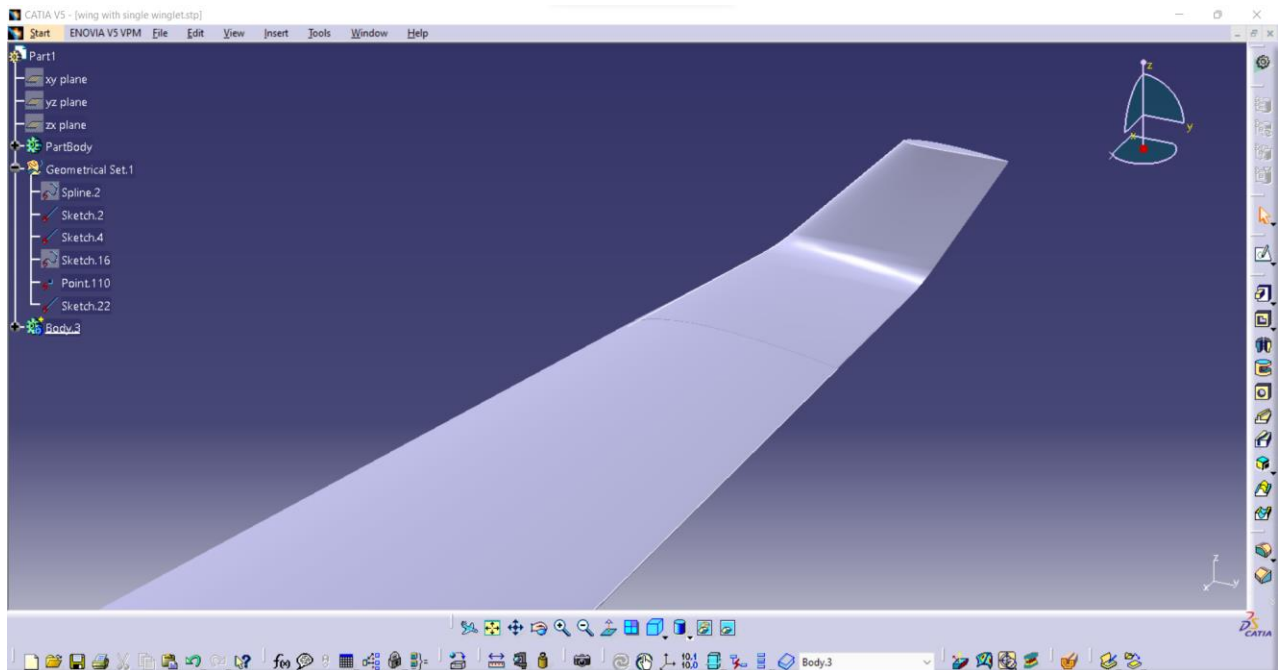
Software Used CATIA V5

Processor : Intel Core i5

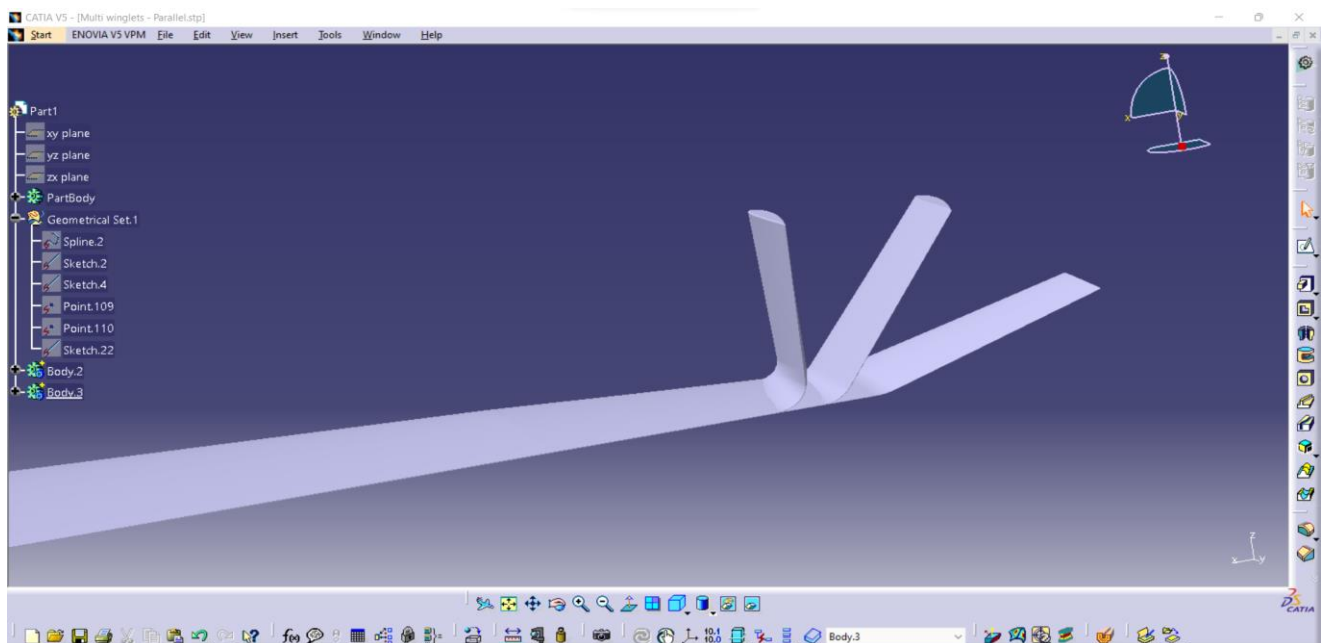
RAM : 8GB

Operating System : Windows 11

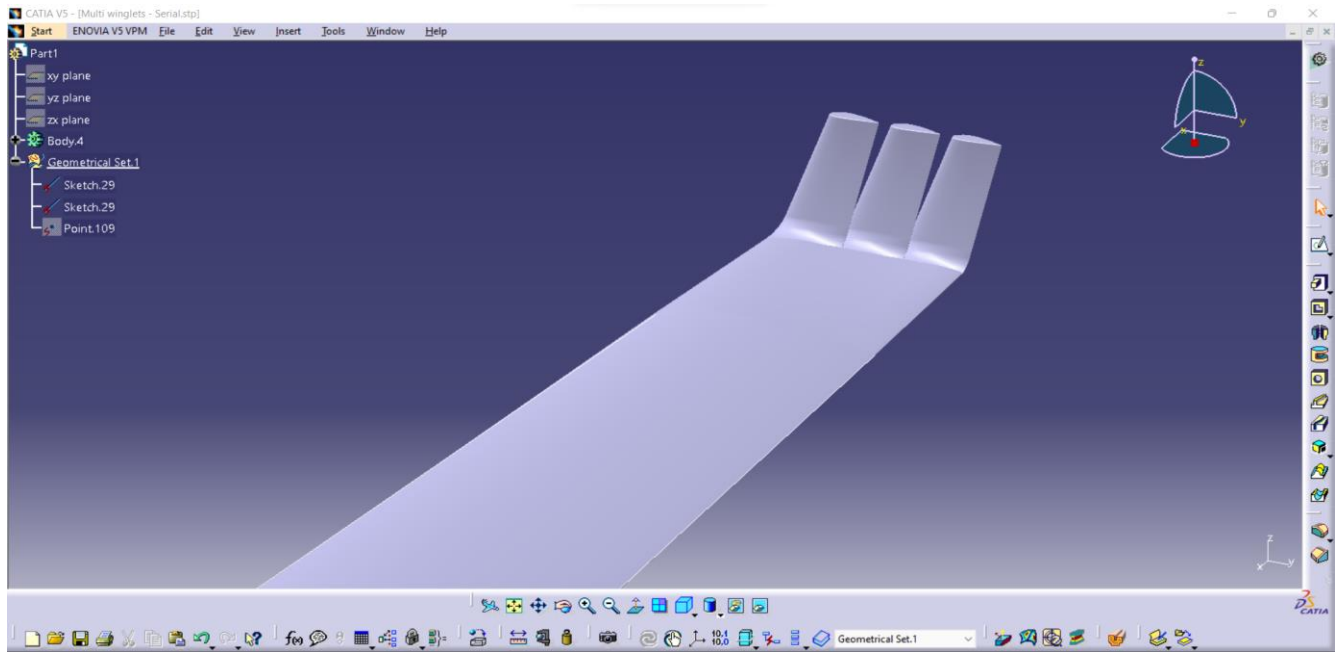
4.1.4 DESIGN MODELS



3D MODEL OF SINGLE WINGLET



3D MODEL OF PARALLEL WINGLET



3D MODEL OF SERIAL WINGLET

CHAPTER - 5

COMPUTATIONAL DOMAIN AND NUMERICAL SIMULATION

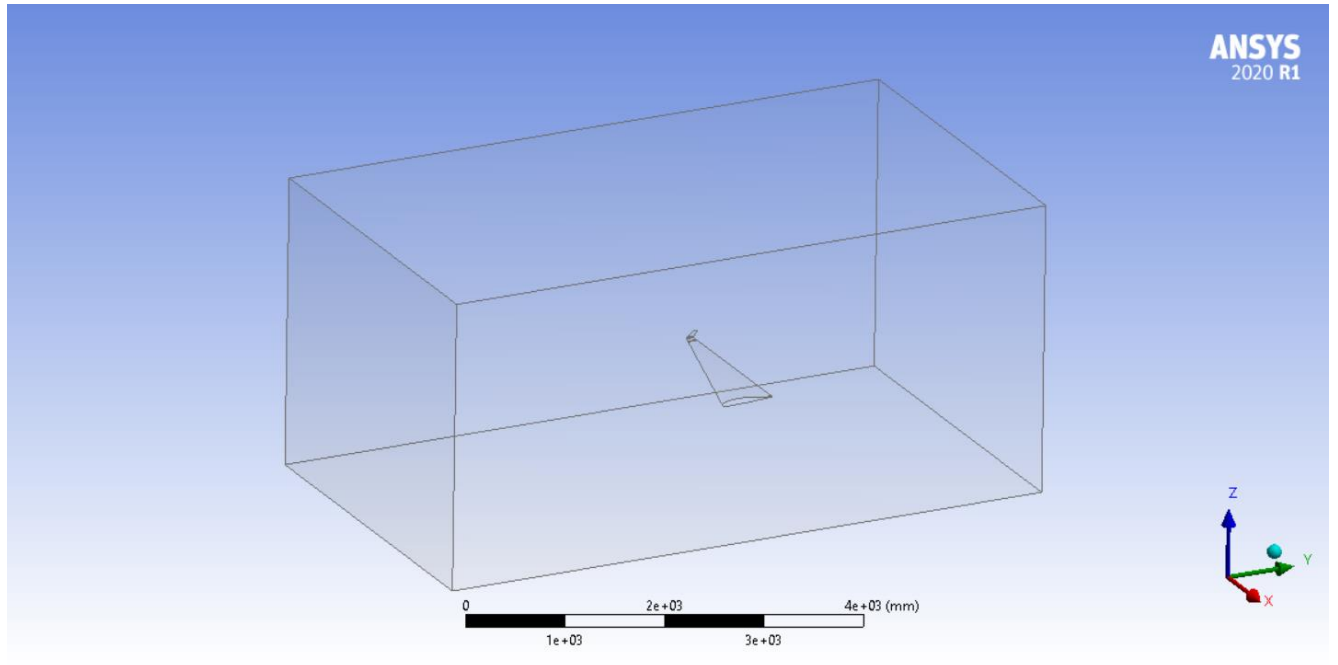
5.1.1) General:

The pre-processing of importing the 3D model of serial winglet and meshing of model has been carried out using ANSYS Fluent code in ANSYS Workbench software. ANSYS Fluent is designed to help analysts and designers build and meshing the models for use in Computational Fluid Dynamics (CFD) and other scientific applications. ANSYS Fluent receives user input by means of its Graphical User Interface (GUI). In this study, the imported model includes the boundary which are modelled by using this software. Meshing is done after the modelling processes.

5.1.2) Boundary creation

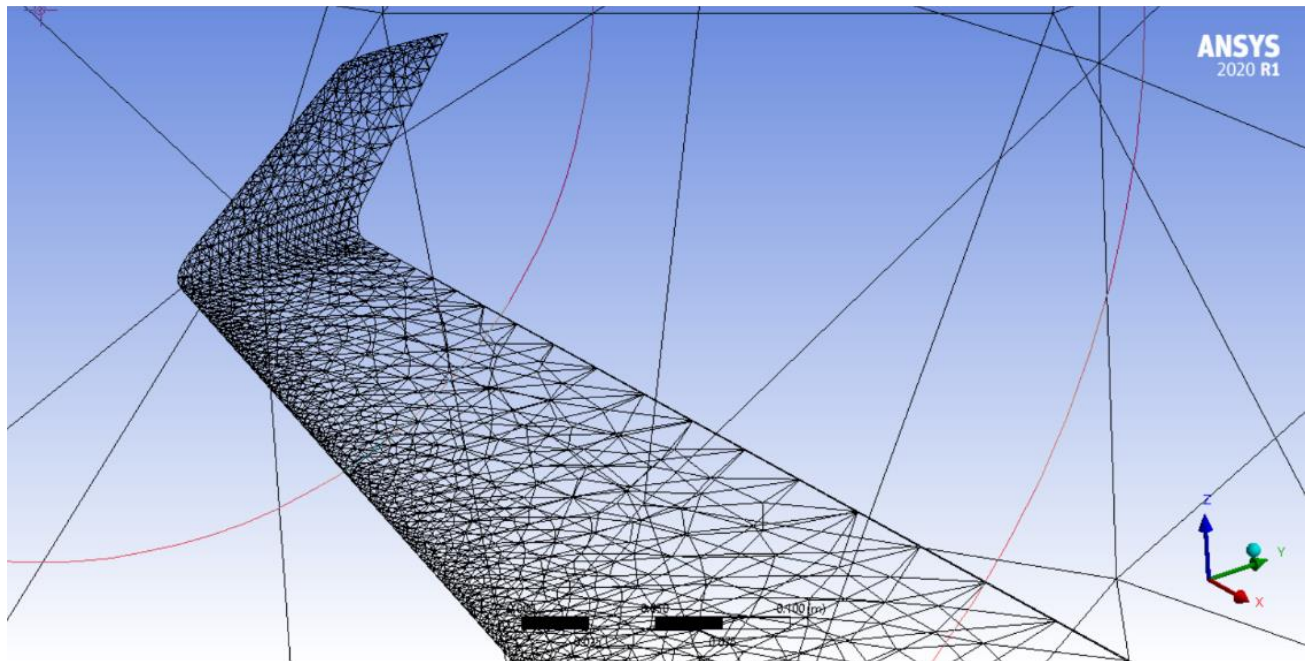
3D model of the single winglet boundary with model is depicted in this Figure below.

GEOMETRY SINGLE WINGLET

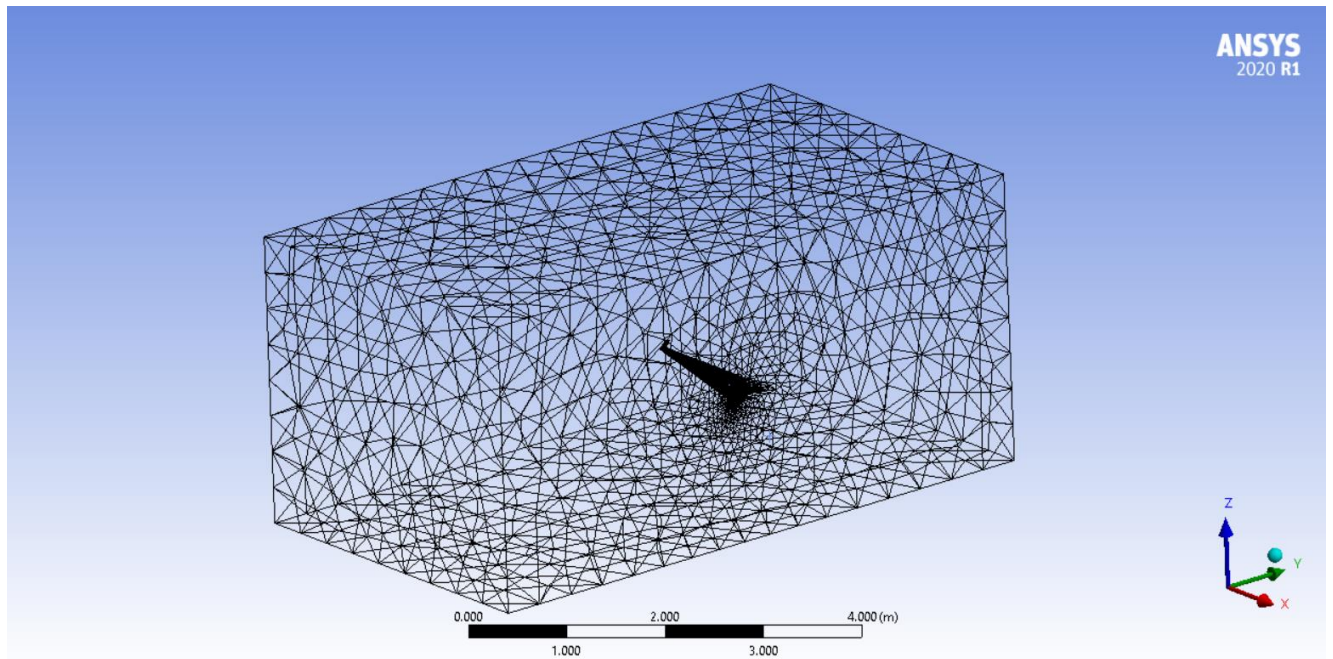


5.1.3) Meshing

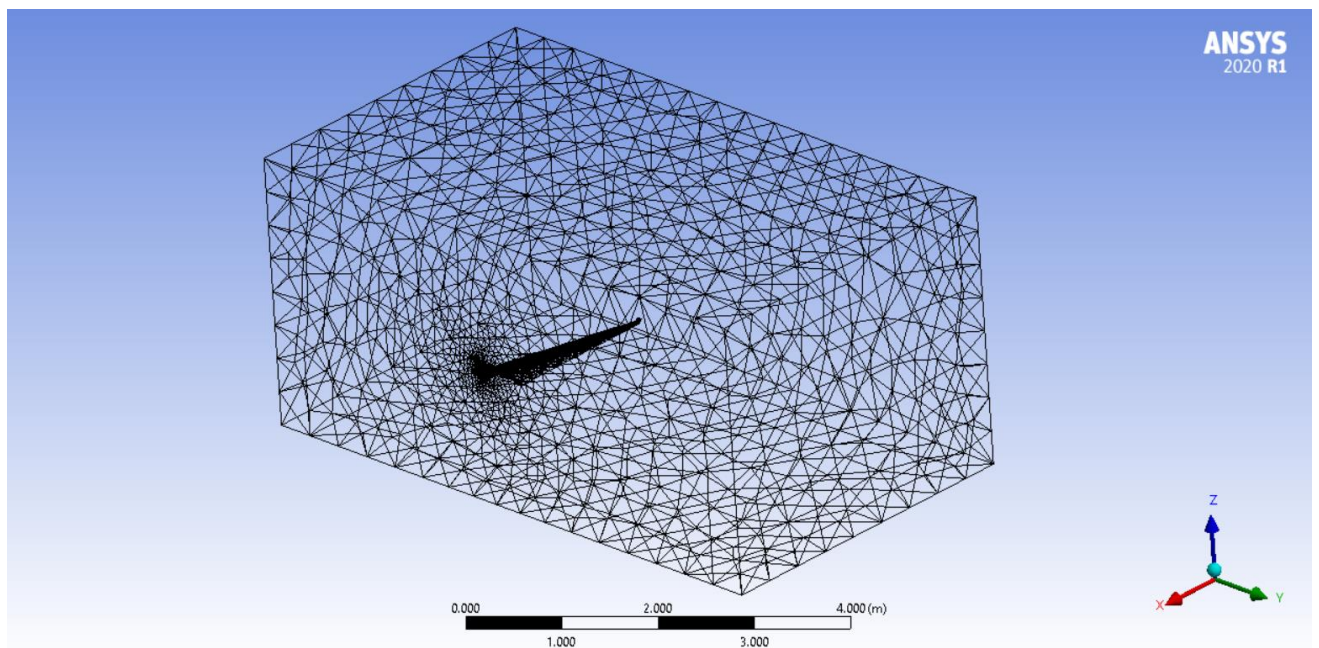
MESHING SINGLE WINGLET



MESHING WITH BOUNDARY 1



MESHING WITH BOUNDARY 2



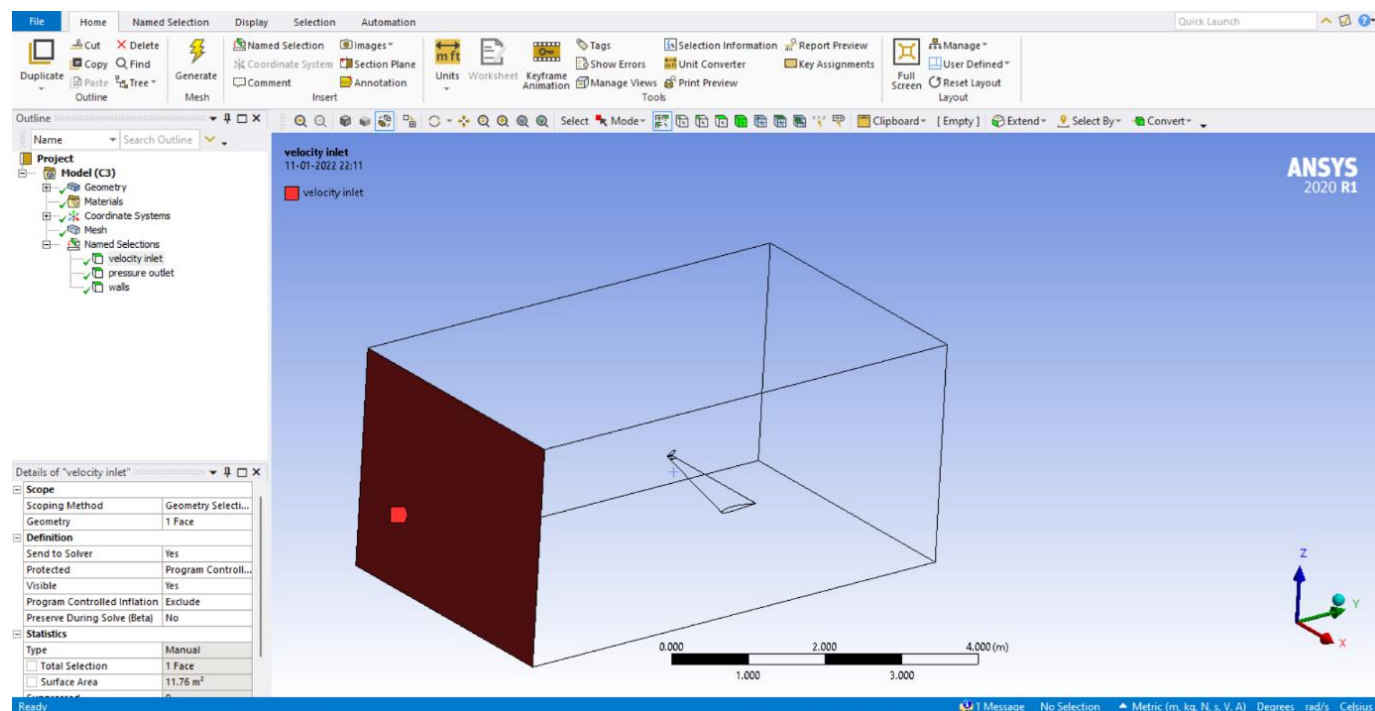
5.1.4) Boundary Plane 1-SINGLE WINGLET

The boundary plane set keeping in mind the axis-symmetric feature. The five boundary conditions set in this modelling are as follows:

- Velocity Inlet Boundary Conditions
- Pressure Outlet Boundary Conditions
- Wall Boundary Conditions

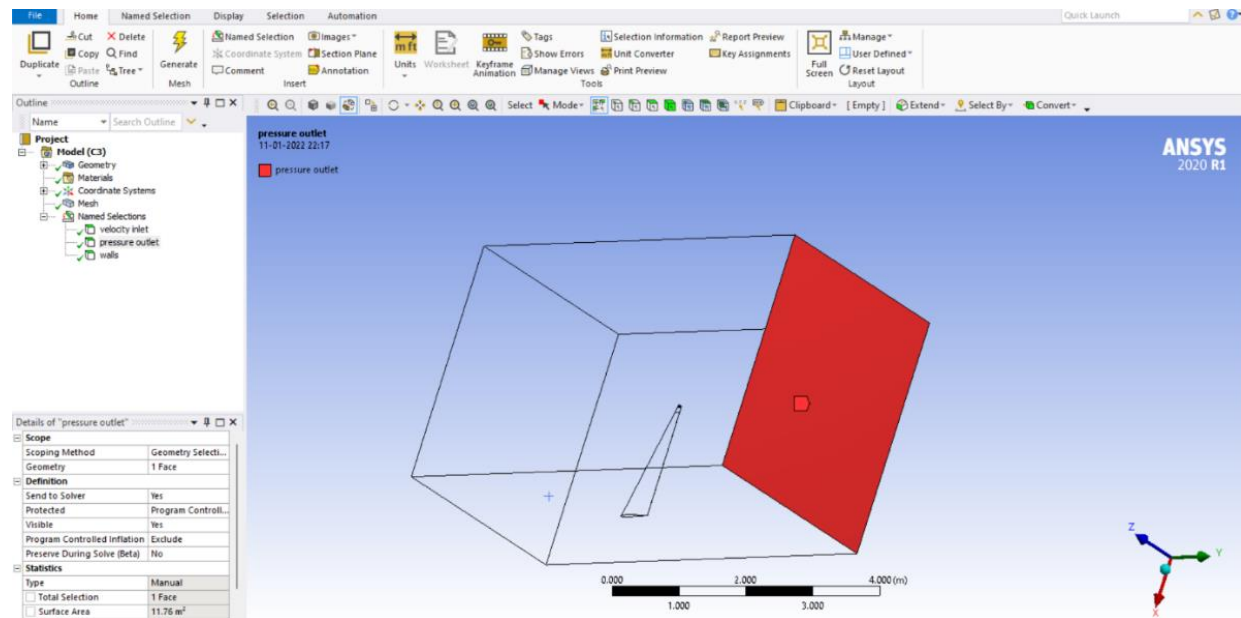
Velocity Inlet Boundary Conditions:

The domain inlet wall is set as velocity inlet boundary. Velocity inlet boundary conditions are used to define the flow velocity, along with the relevant scalar properties of the flow inlets. The total (or Stagnation) properties of the flow are not fixed, so they will rise to whatever value is necessary to provide the prescribed velocity distribution.



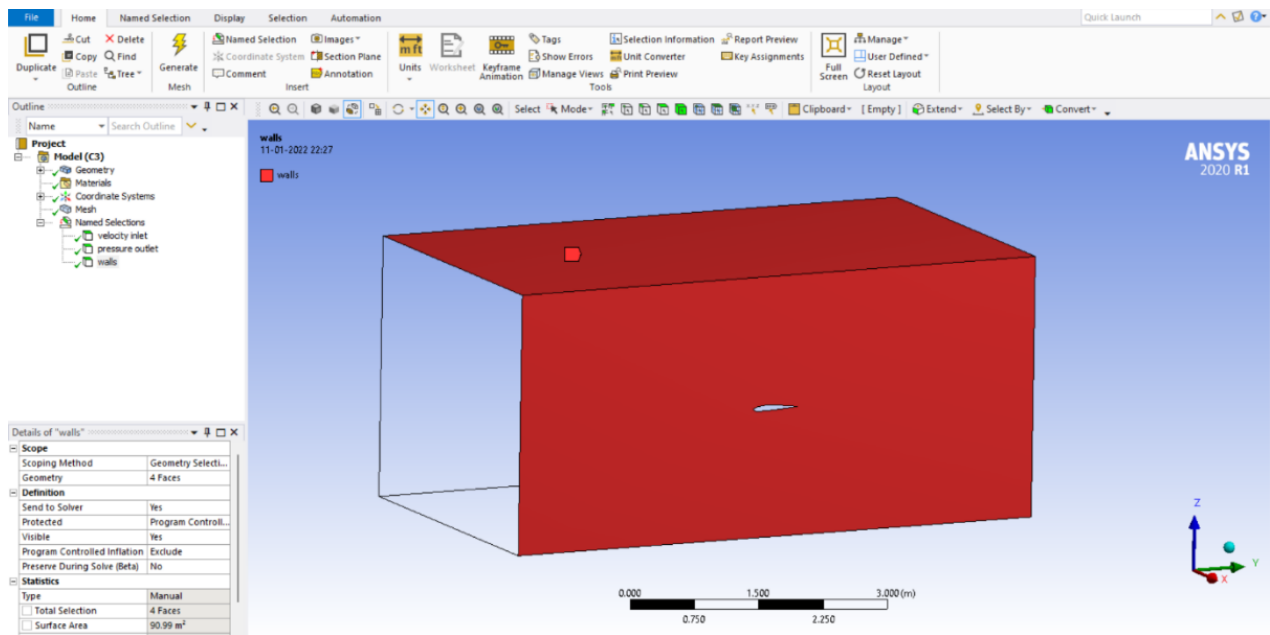
Pressure Outlet Boundary Conditions

The domain outlet wall is set as a Boundary Pressure outlet boundary. Pressure outlet boundary conditions require the specification of a static(gauge) pressure at the outlet boundary. The value of static pressure specified is used only while the flow is subsonic.



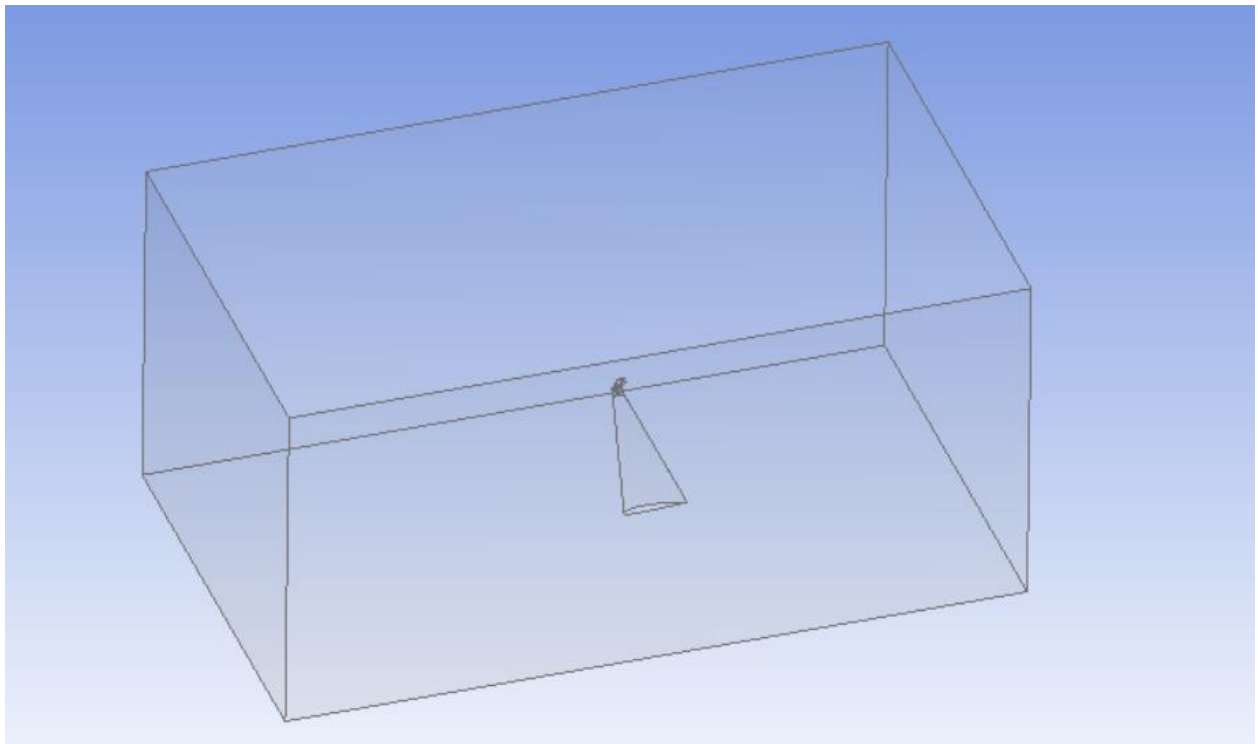
Wall Boundary Conditions

The model wall is set as wall boundary. Wall boundary conditions are used to bound fluid and solid regions. In viscous flows, the no-slip boundary conditions is enforced at walls by default, but it can be specified that a tangential velocity component in terms of translational or rotational motion of the wall boundary, or model a slip wall by specifying shear. The shear stress and the heat transfer between the fluid and wall are computed based on the flow details in the local flow field.



5.1.5) Boundary creation 2

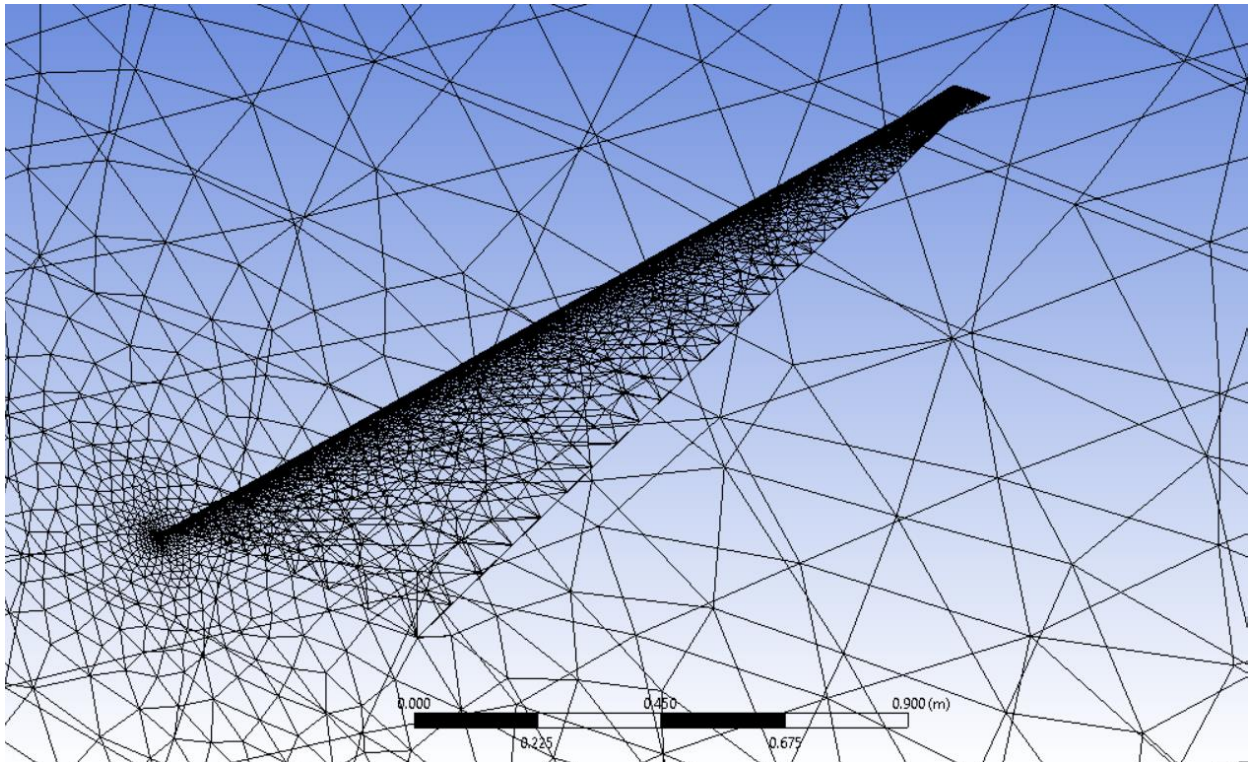
3D model of the parallel winglet boundary with model is depicted in this Figure below.



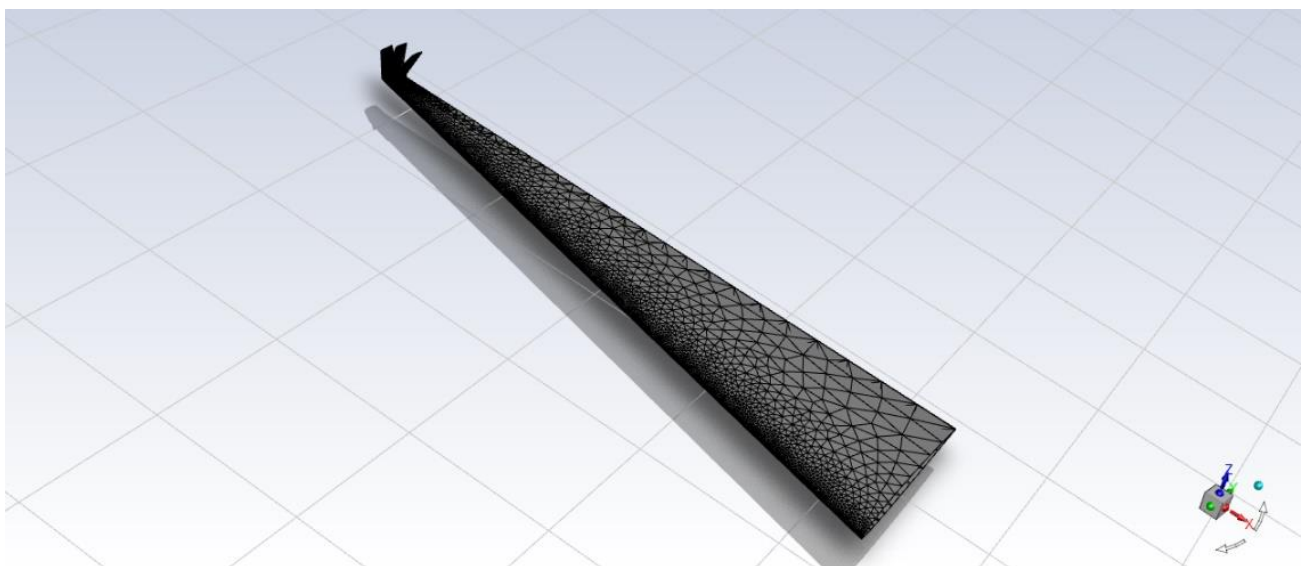
5.1.6) Meshing

MESHING PARALLEL WINGLET

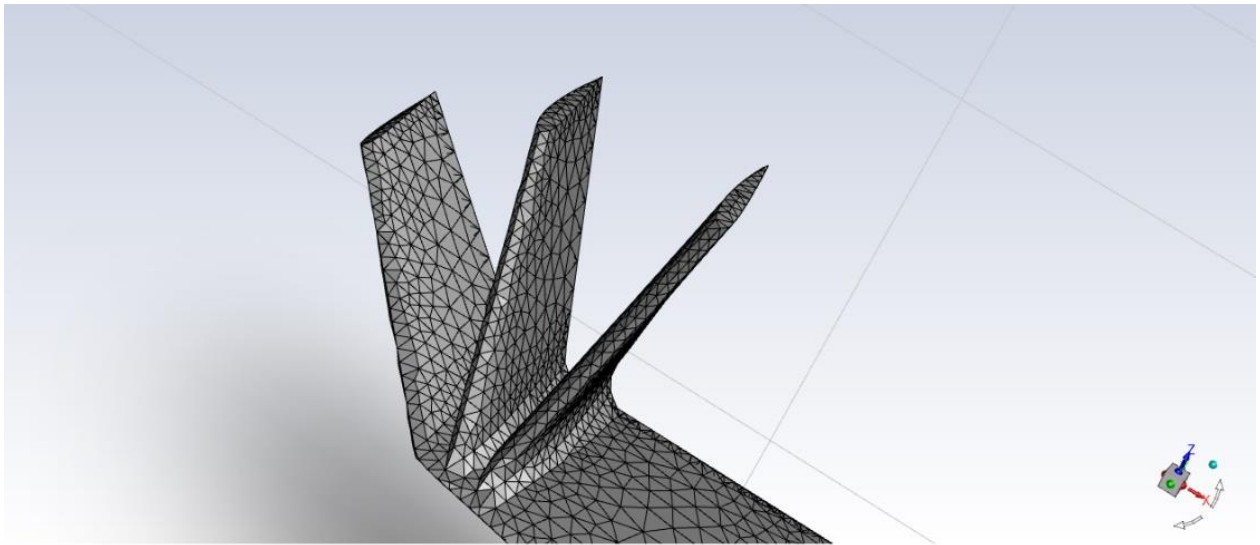
MESH AROUND WING WITH PARALLEL WINGLETS



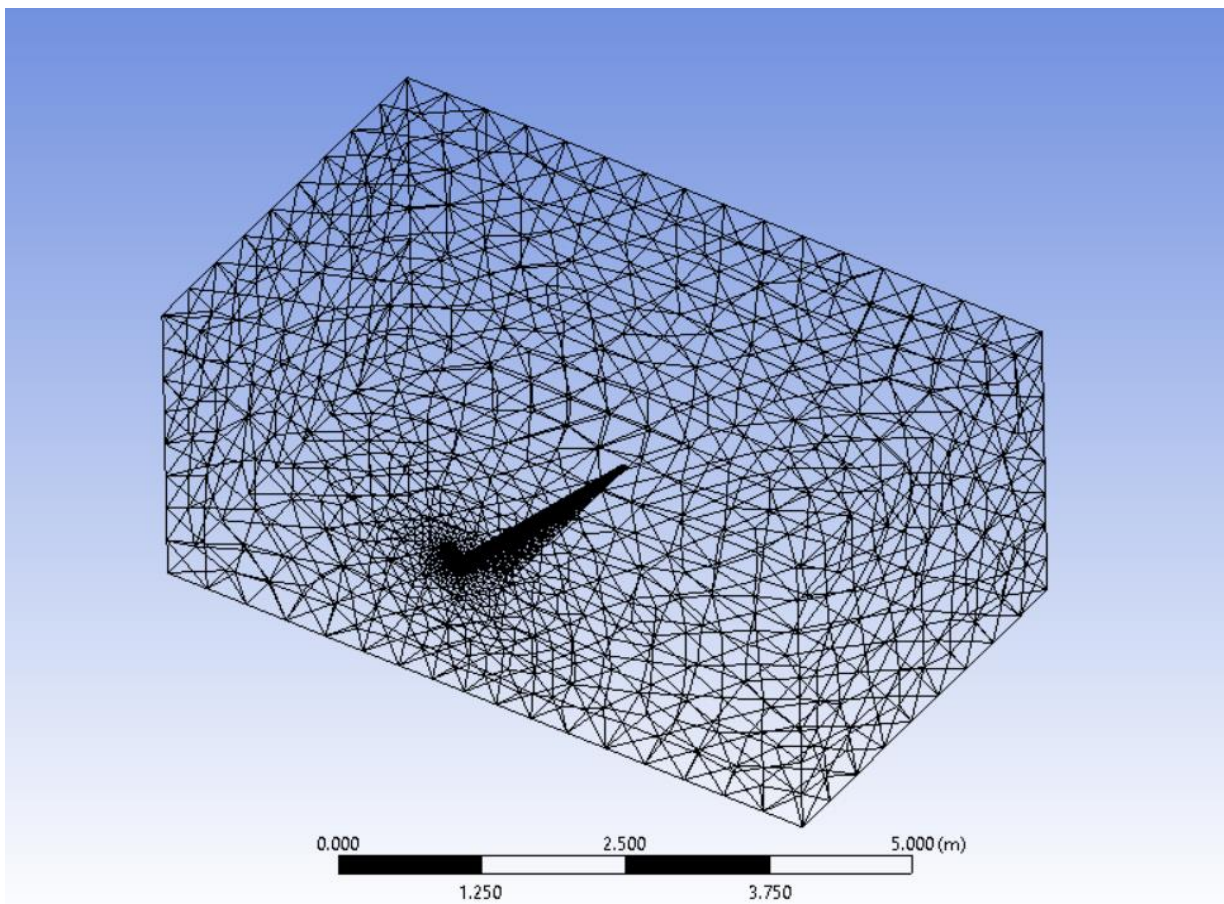
MESHING PARALLEL WINGLETS



MESHING PARALLEL WINGLETS-2



MESHING WITH BOUNDARY



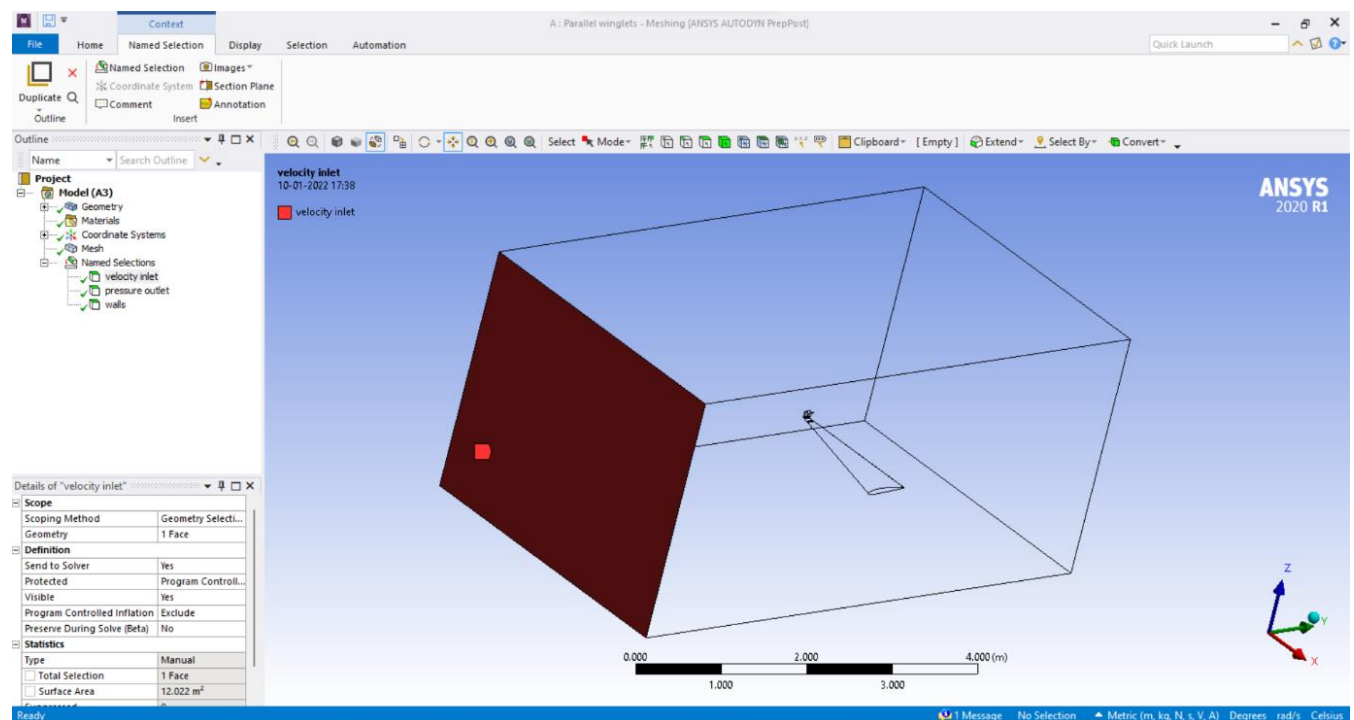
5.1.7) Boundary Plane 2-PARALLEL WINGLET

The boundary plane set keeping in mind the axis-symmetric feature. The five boundary conditions set in this modelling are as follows:

- Velocity Inlet Boundary Conditions
- Pressure Outlet Boundary Conditions
- Wall Boundary Conditions

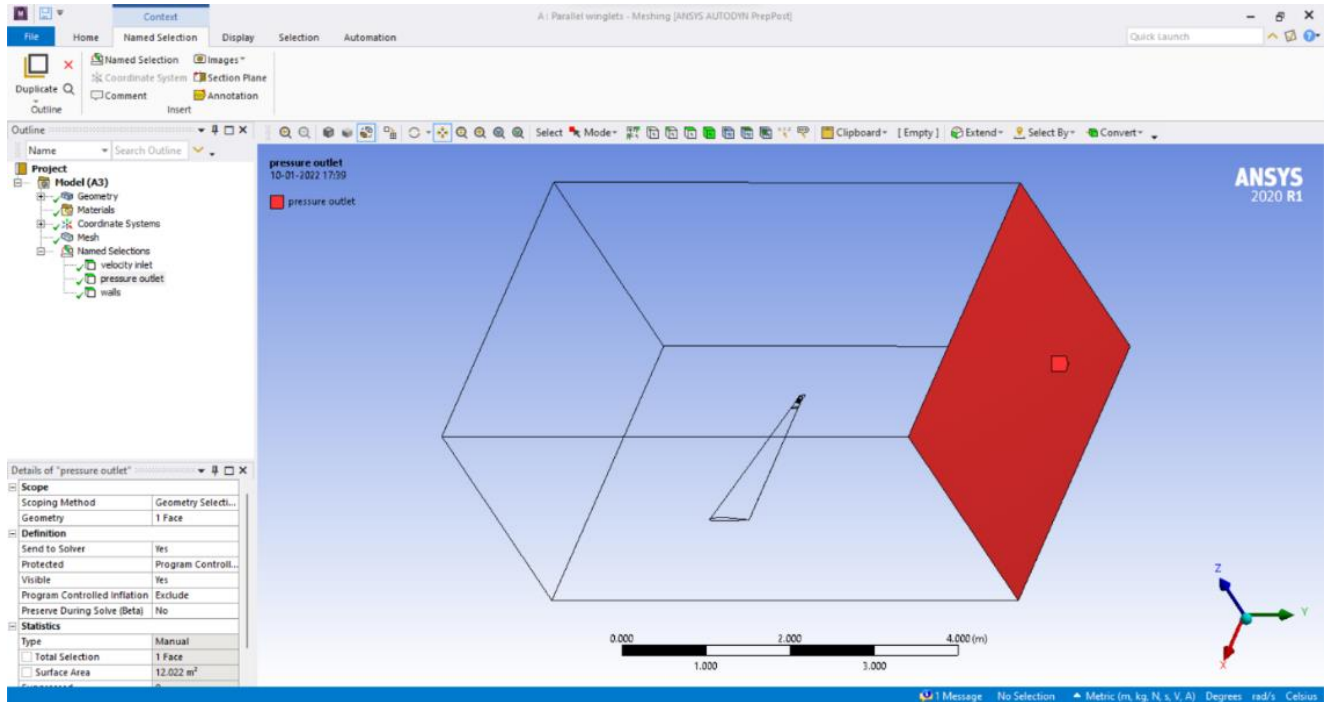
Velocity Inlet Boundary Conditions:

The domain inlet wall is set as velocity inlet boundary. Velocity inlet boundary conditions are used to define the flow velocity, along with the relevant scalar properties of the flow flow inlets. The total (or Stagnation) properties of the flow are not fixed, so they will rise to whatever value is necessary to provide the prescribed velocity distribution.



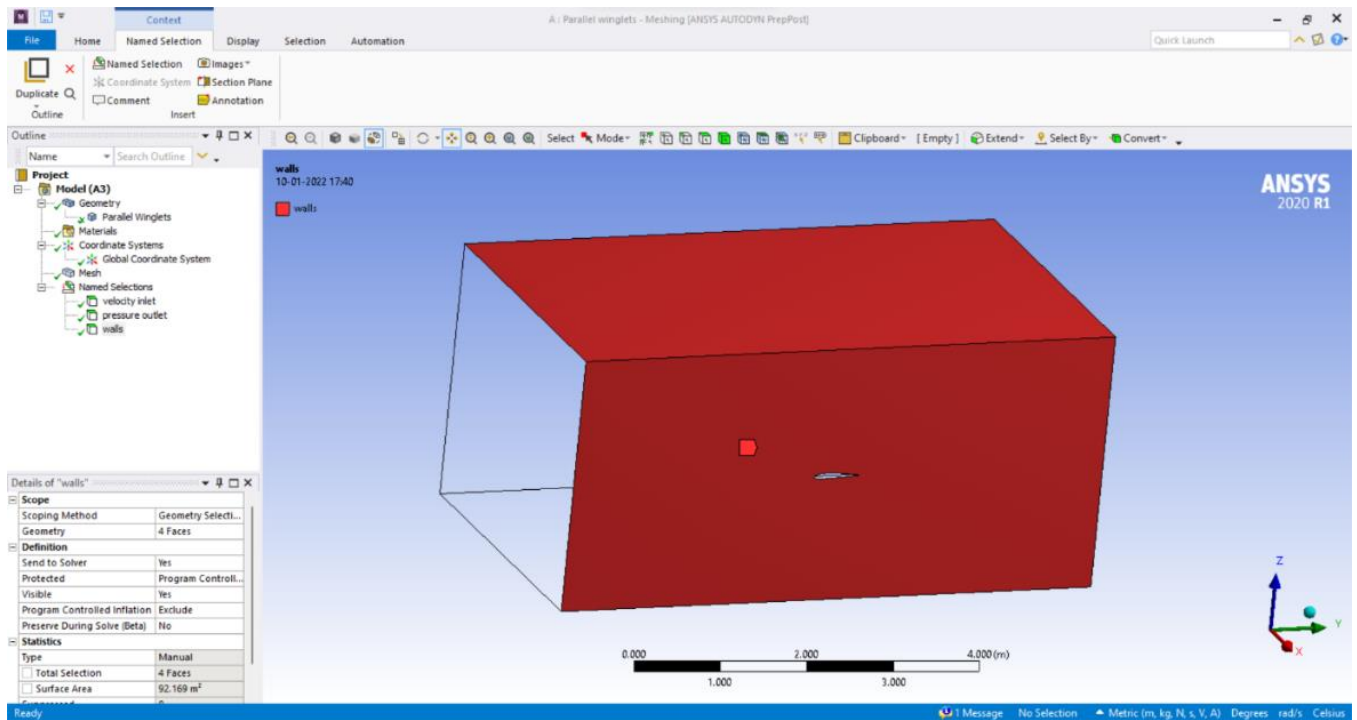
Pressure Outlet Boundary Conditions -

The domain outlet wall is set as a Boundary Pressure outlet boundary. Pressure outlet boundary conditions require the specification of a static(gauge) pressure at the outlet boundary. The value of static pressure specified is used only while the flow is subsonic.



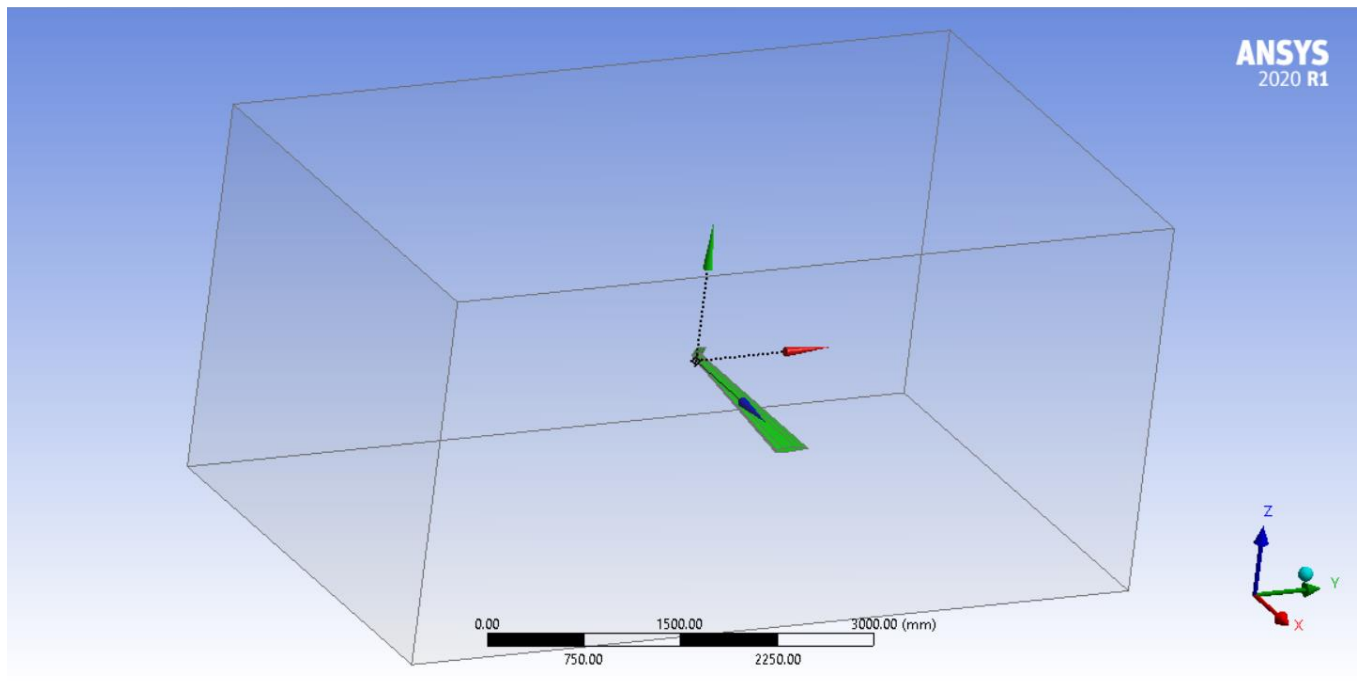
Wall Boundary Conditions -

The model wall is set as wall boundary. Wall boundary conditions are used to bound fluid and solid regions. In viscous flows, the no-slip boundary conditions is enforced at walls by default, but it can be specified that a tangential velocity component in terms of translational or rotational motion of the wall boundary, or model a slip wall by specifying shear. The shear stress and the heat transfer between the fluid and wall are computed based on the flow details in the local flow field.



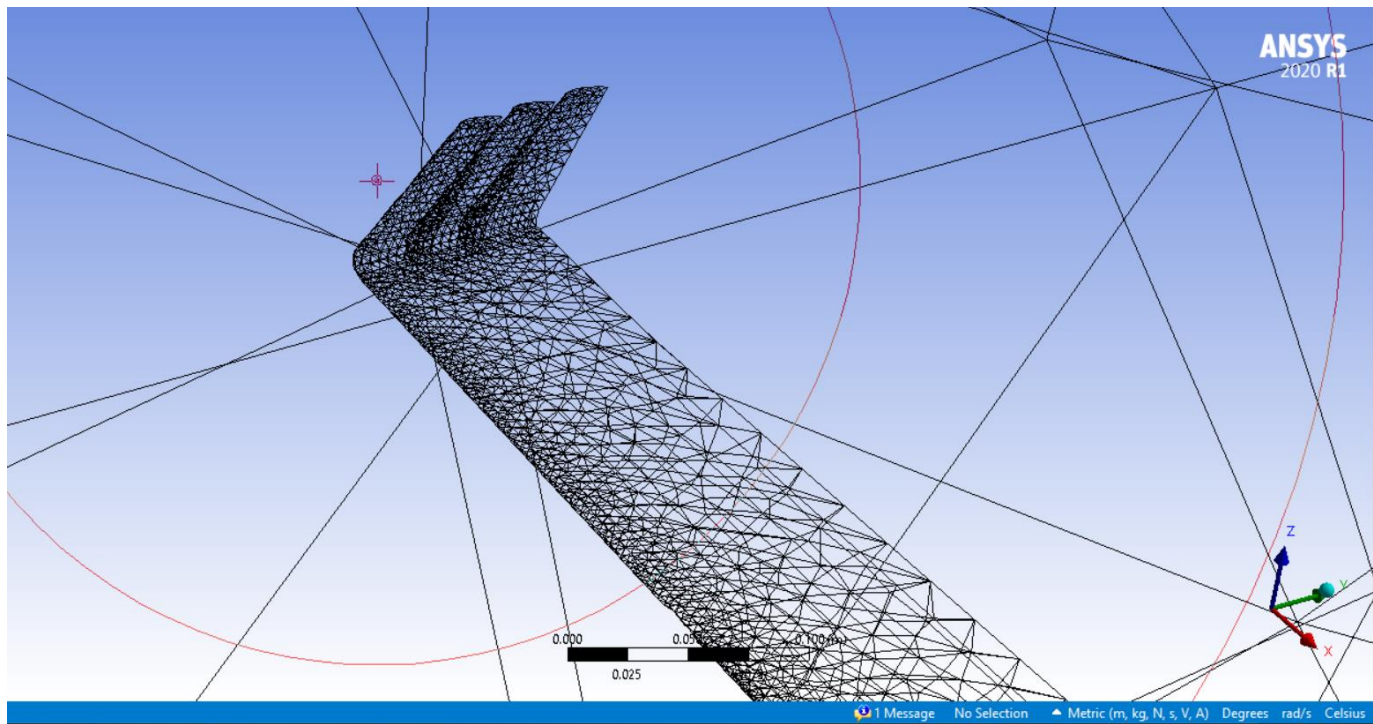
5.1.8) Boundary creation: - 3

3D model of the serial winglet boundary with model is depicted in this Figure below.

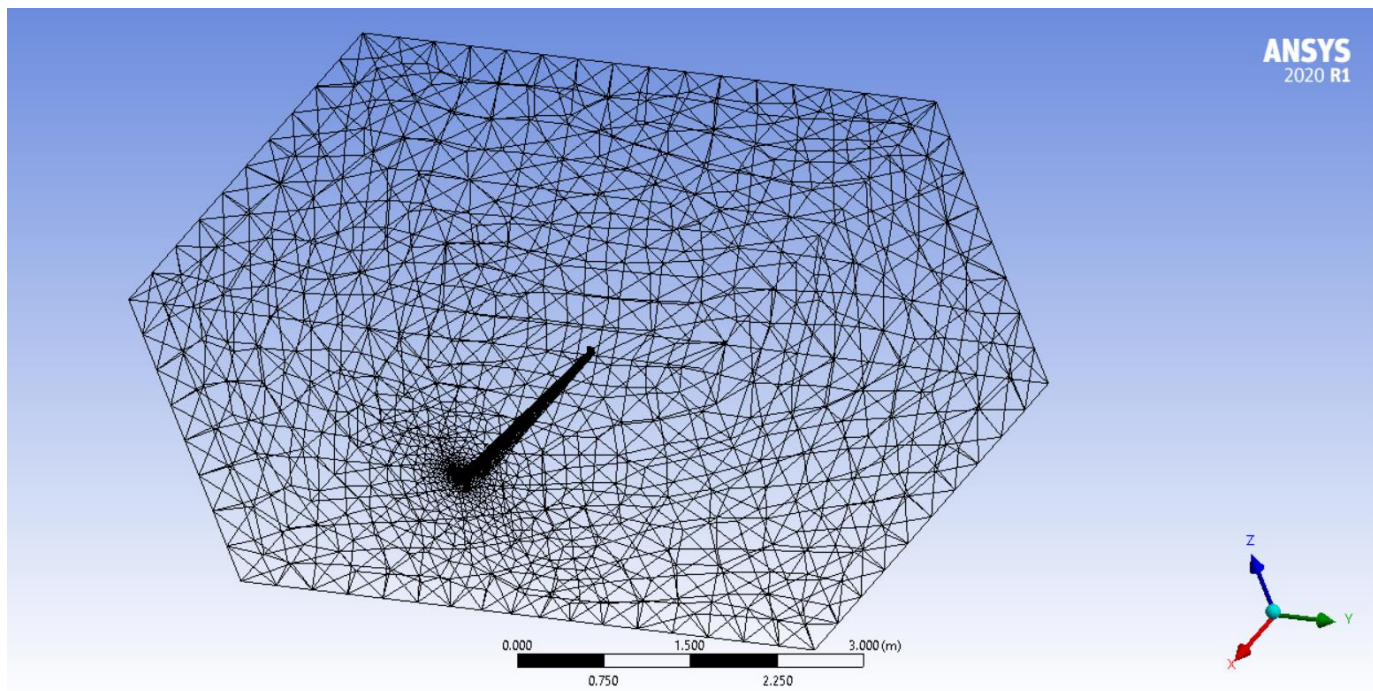


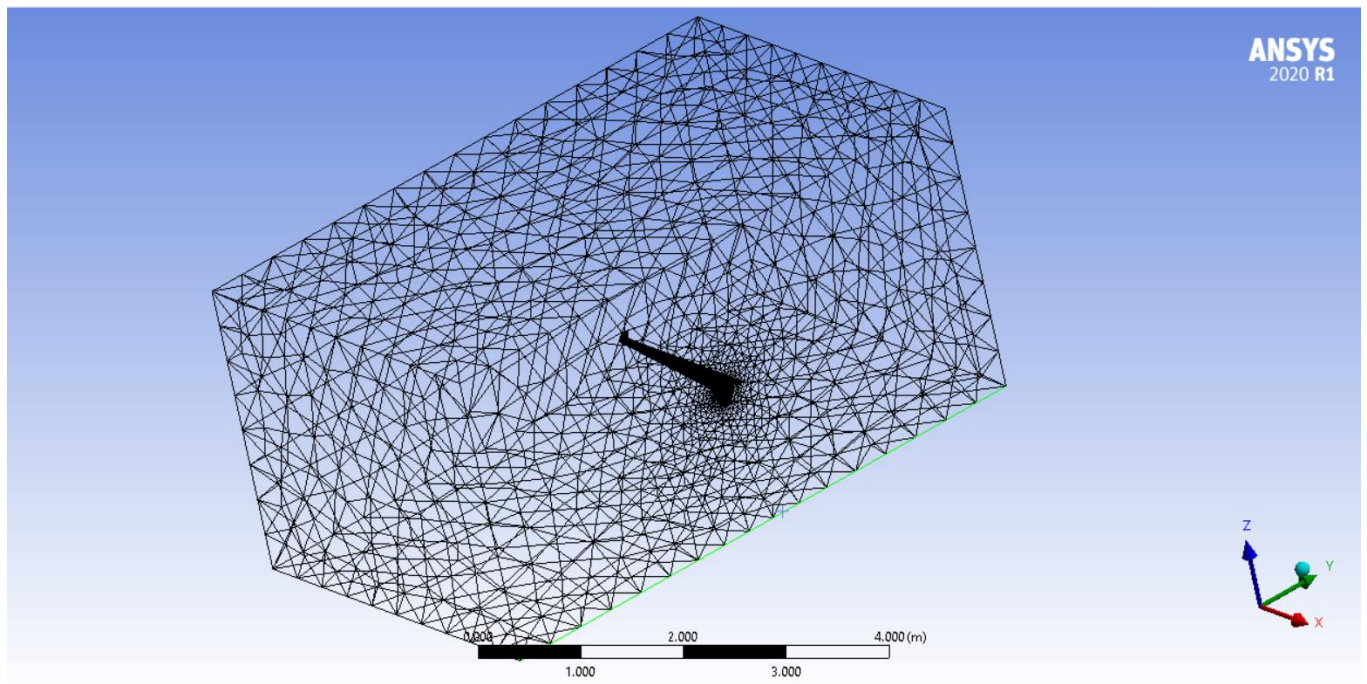
5.1.9) Meshing -

MESHING SERIAL WINGLET



MESHING WITH BOUNDARY 1





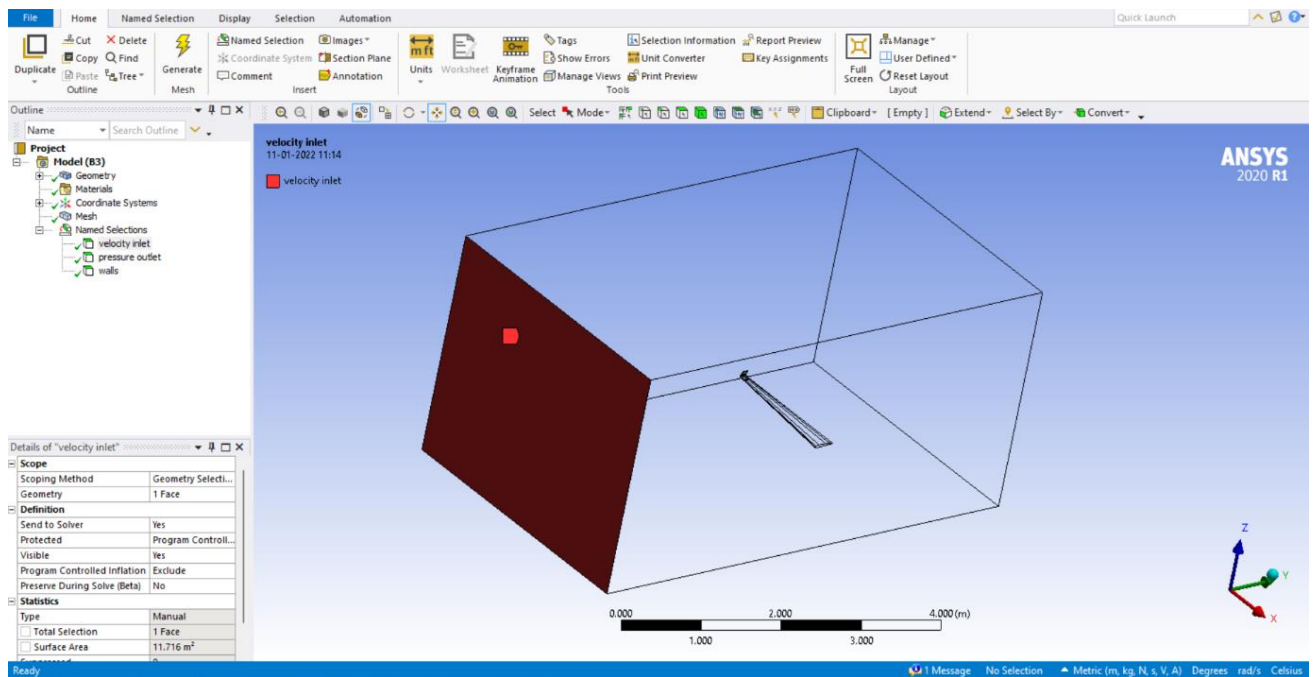
5.1.10) Boundary Plane 3-SERIAL WINGLET

The boundary plane set keeping in mind the axis-symmetric feature. The five boundary conditions set in this modelling are as follows:

- Velocity Inlet Boundary Conditions
- Pressure Outlet Boundary Conditions
- Wall Boundary Conditions

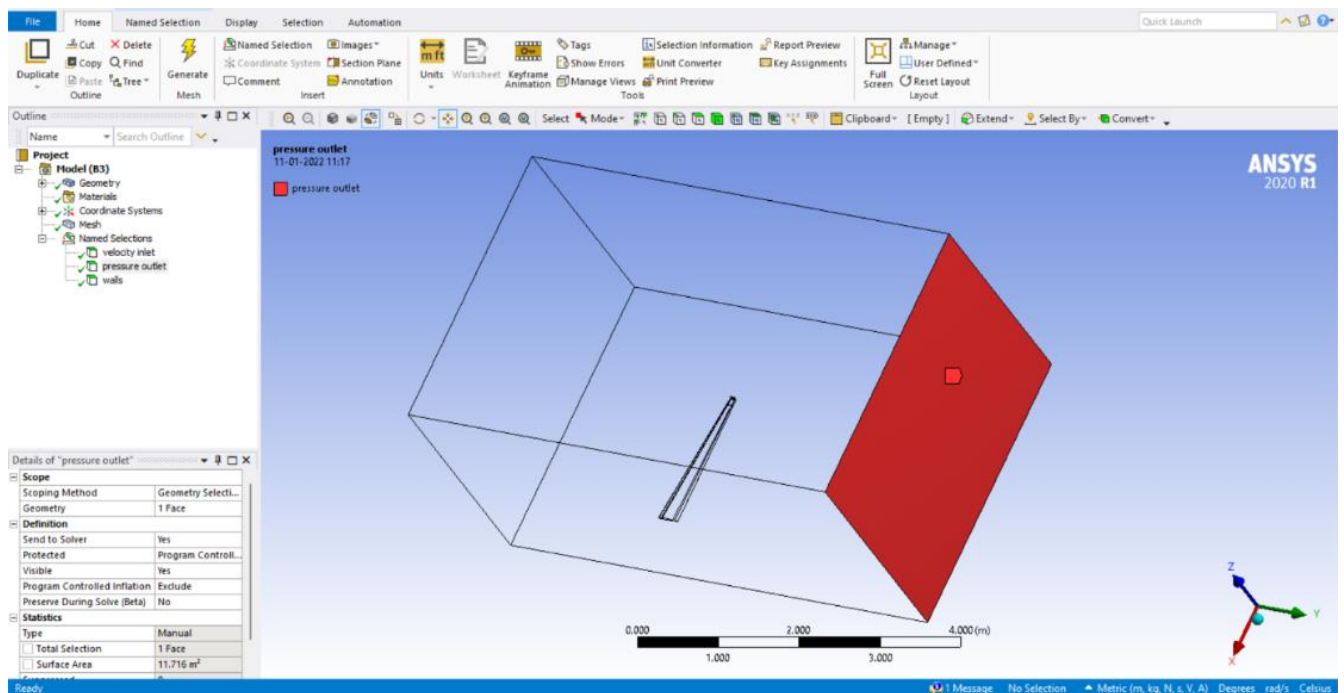
Velocity Inlet Boundary Conditions:

The domain inlet wall is set as velocity inlet boundary. Velocity inlet boundary conditions are used to define the flow velocity, along with the relevant scalar properties of the flow flow inlets. The total (or Stagnation) properties of the flow are not fixed, so they will rise to whatever value is necessary to provide the prescribed velocity distribution.



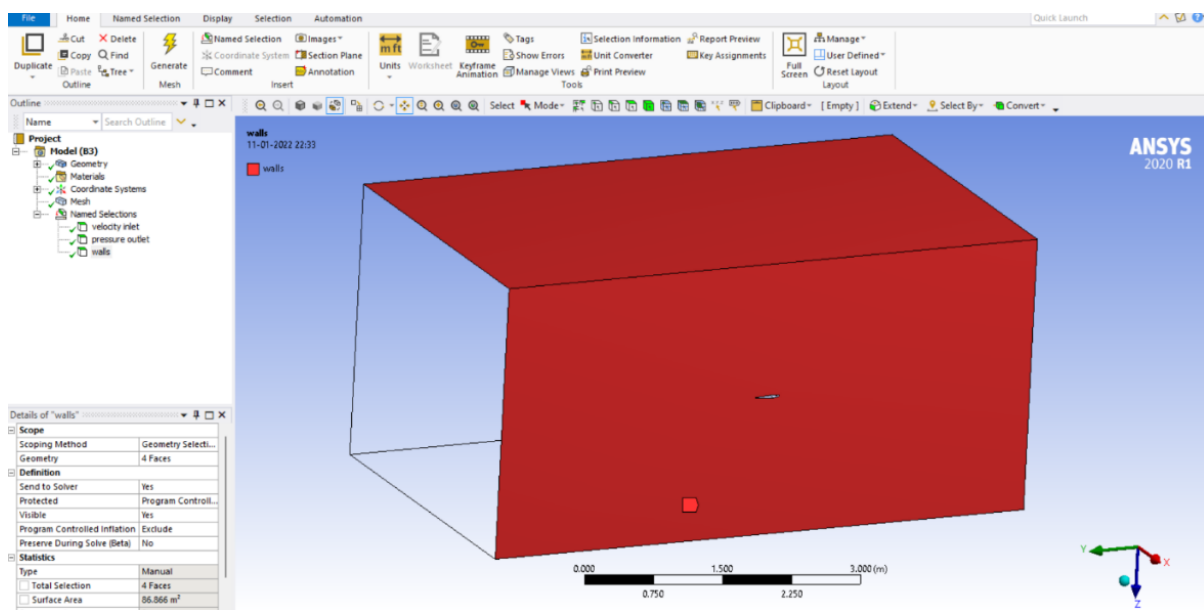
Pressure Outlet Boundary Conditions -

The domain outlet wall is set as a Boundary Pressure outlet boundary. Pressure outlet boundary conditions require the specification of a static(gauge) pressure at the outlet boundary. The value of static pressure specified is used only while the flow is subsonic.



Wall Boundary Conditions-

The model wall is set as wall boundary. Wall boundary conditions are used to bound fluid and solid regions. In viscous flows, the no-slip boundary conditions is enforced at walls by default, but it can be specified that a tangential velocity component in terms of translational or rotational motion of the wall boundary, or model a slip wall by specifying shear. The shear stress and the heat transfer between the fluid and wall are computed based on the flow details in the local flow field.



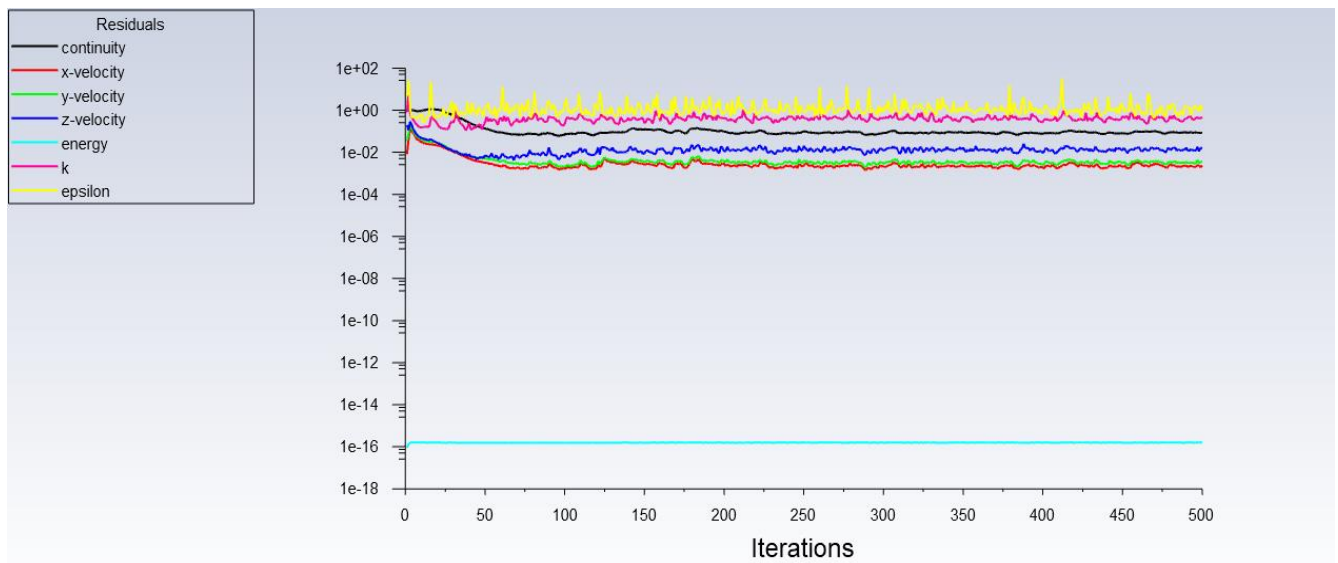
CHAPTER -6

6.1.1) NUMERICAL SIMULATION USING FLUENT (*OVERVIEW OF FLUENT*):

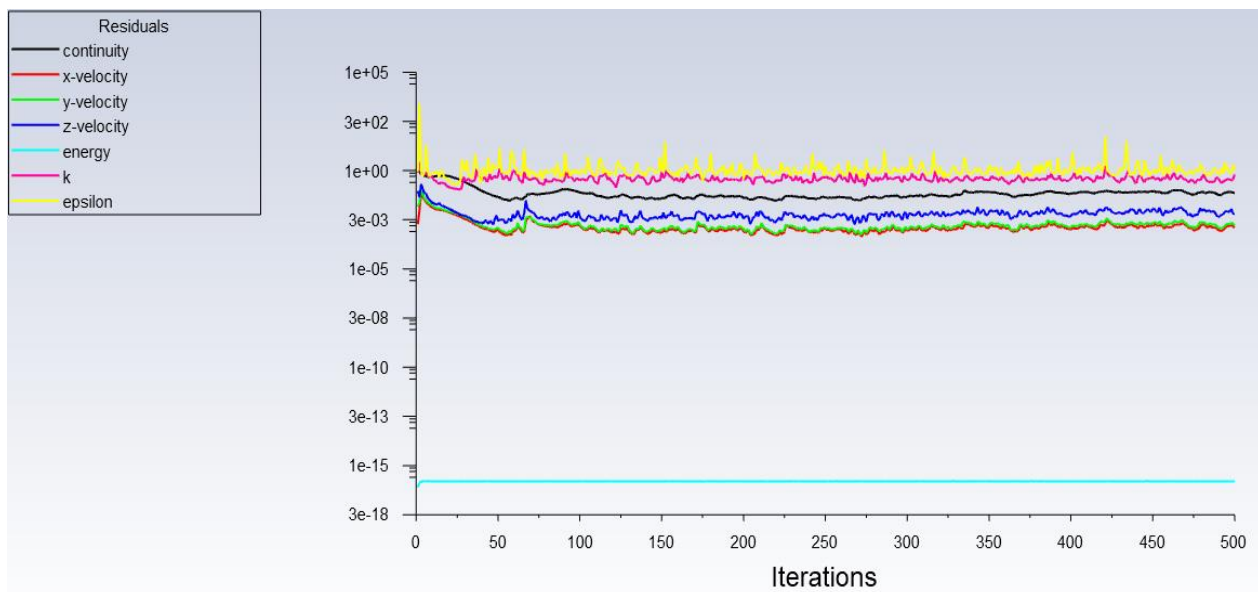
Numerical simulation has been carried using fluent software. This software used for modelling fluid flow and heat transfer in complex geometries. It provides complete mesh flexibility including the ability to solve the flow problems using unstructured meshes that can be generated about complex geometries with the relative ease. It is written in the C computer language and makes full use of the flexibility and power offered by the language. All functions required to compute a solution and display the results are accessible in FLUENT through an interactive menu-driven interface. The reference procedural steps for solving a problem in FLUENT include

- 1) Define the modeling goals
- 2) Create the model geometry and grid
- 3) Set up the solver and physical models
- 4) Compute and monitor the solution
- 5) Examine and save the results
- 6) Consider revisions to the numerical or physical model parameters, if necessary

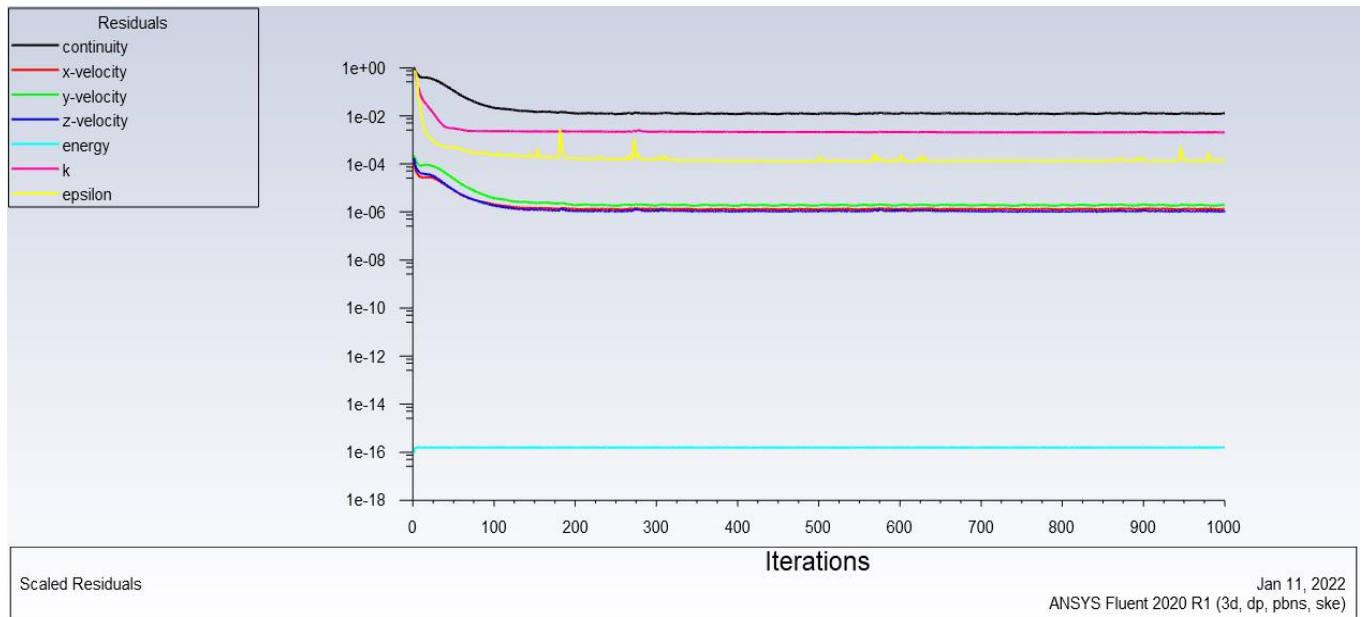
1A) SINGLE WINGLET RESIDUAL MONITORS; -



2B) PARALLEL WINGLET RESIDUAL MONITORS; -



3C) SERIAL WINGLET RESIDUAL MONITORS-



6.1.2) COMPUTATION DOMAIN NUMERICAL SIMULATION

computational fluid dynamics (CFD) modelling (or field modelling) is becoming the main method for numerical simulation of building fires

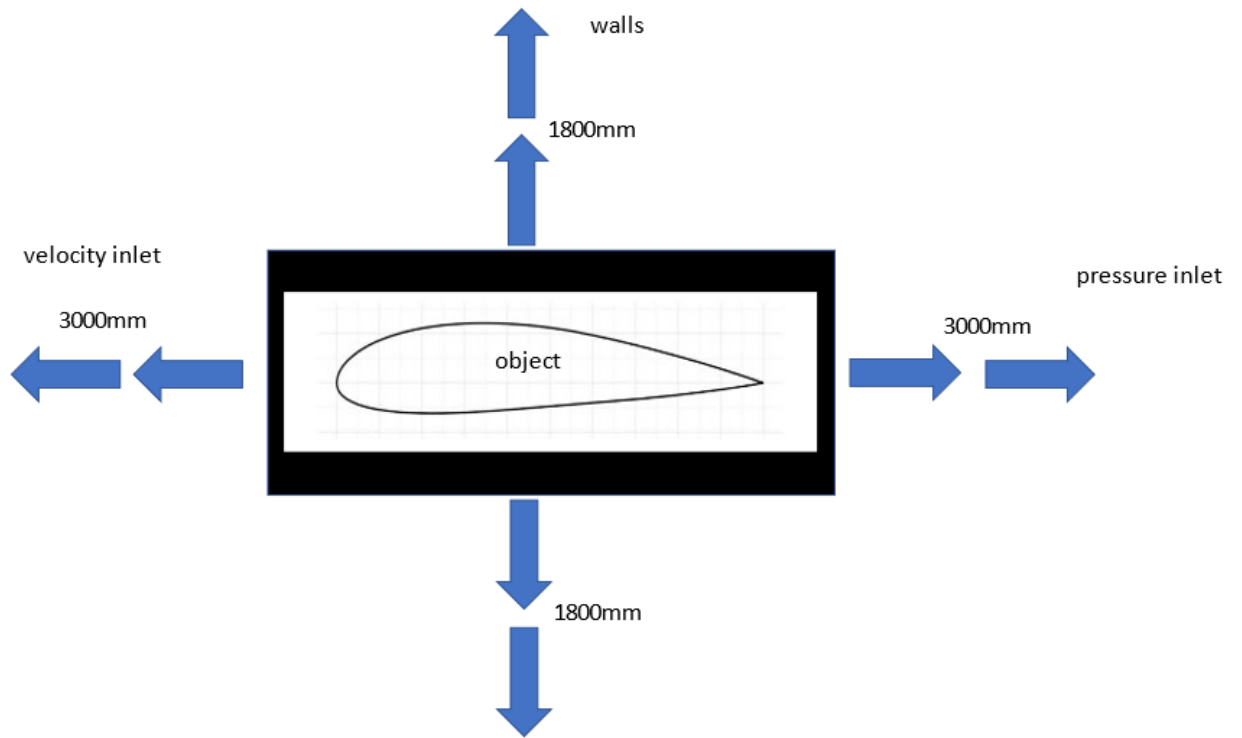
. among many factors that influence the validity and accuracy of CFD simulation results, the computational domain is sometimes overlooked.

in this article, the effects of computational domain on simulation results are analysed. simulation results from the use of different domains are compared with experimental data reported in the literature.

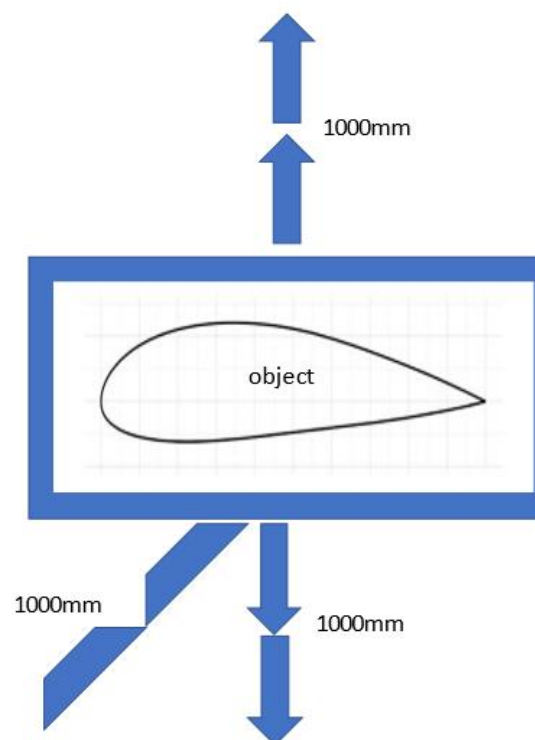
a parametric study is then conducted to reveal a relationship between the effective domain extension and the heat release rate of the enclosure fire.

the effect of computational domain extension in relation to vent opening is also investigated. it is found that the selection of computational domain can have a significant effect on the outcome of enclosure fire simulations.

determination of the appropriate computational domain without unduly sacrificing computational efficiency is also discusses



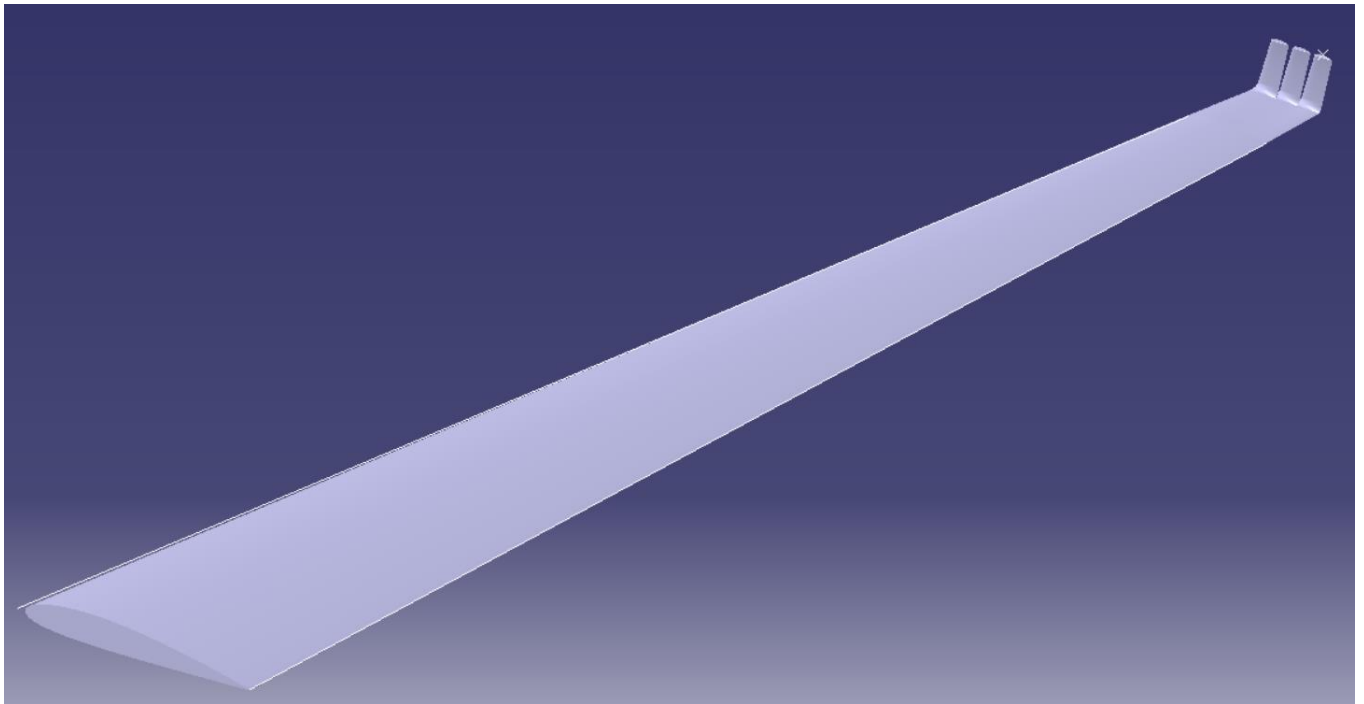
FRONT VIEW



6.1.3). serial Winglet Template

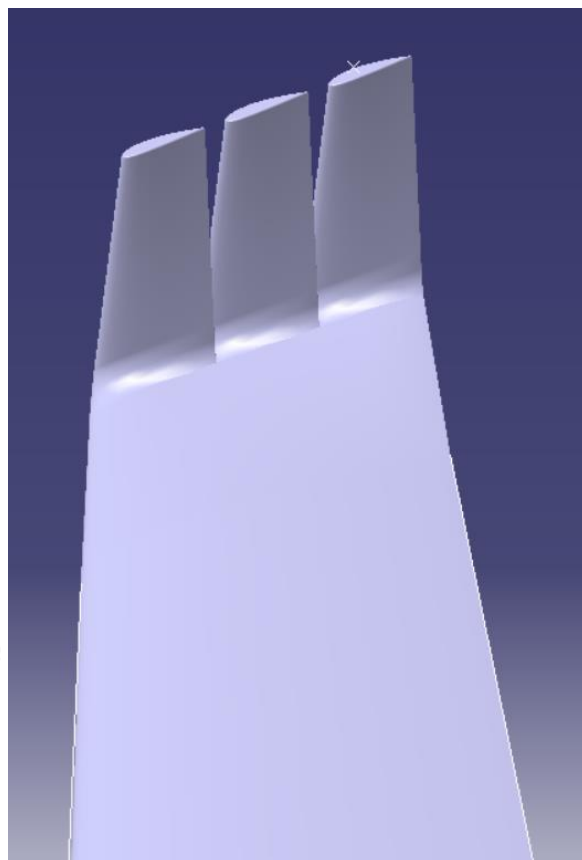
Serial winglet template has been modelled with three different sections namely upward winglet backward winglet and downward winglet serial base is a shape design model where it forms the intersection at the main wing tip chord and continues as a smooth curve to avoid the interference drag. The leading edge of serial base is formed by the conic section which depends on sweep plane, two tangent lines and two points which lies on the same plane. Radius of the leading edge could be varied by a real parameter and also it depends on base height associated with height parameter. The other parameters controlling the serial base were serial span, can't angle, sweep angle and tip chord length Can't and Sweep angles are made with respect to the base span line and not from root chord of the base. The later section i.e., the skeleton model of serial vertical is created in dependent with the serial base. The leading edge is made tangent with the base leading-edge curve in order to obtain a smooth surface. Serial vertical is also associated with a set of parameters which are height and tip chord length. Vertical and horizontal reference area of the serial template model are calculated and given as an output parameter The height parameter for both sections of serial template does not represent the vertical height but the length of respective lines. The exact vertical height for the serial template is given as an output parameter named "reference leading edge vertical" from which the reference area is calculated based on the root chord and tip chord of the respective section Similarly, the horizontal span of entire blended section varies with the cant angle and also with base span length.

SERIAL WINGLET



WINGTIPS

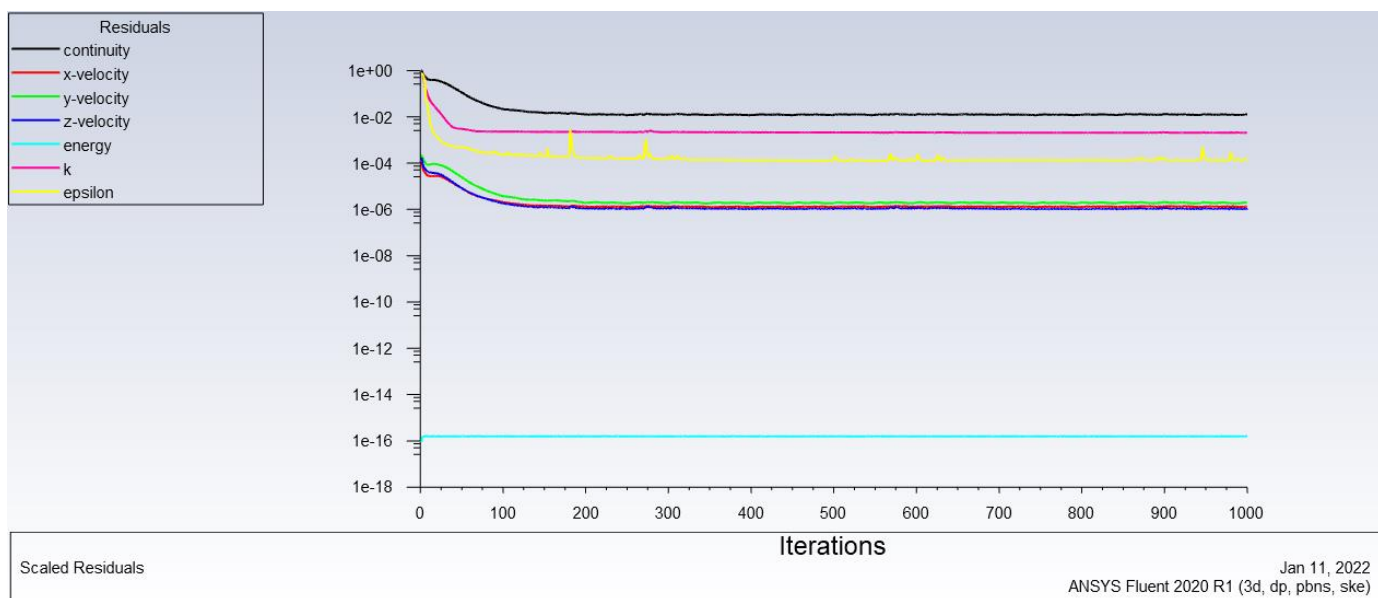
Parameters	
cantAngle=	25deg
sweepAngle=	35deg
tipBase=	1600mm
baseSpan=	600mm
lengthLEVertical=	1000mm
lengthLeadingEdge=	1200mm
tipChord=	900mm
airfoilType=	withThicknessTE
radius=	0,8
rootChord=	2500mm
refLEHorizontal=	1529,76mm
horizontalAreaWithCant=	1,581m2
refVerticalArea=	2,777m2
refLEVertical=	1633,289mm
verticalheight=	742,404mm
baseHeight=	890,885mm
totalHorizontalAreaRef=	3,081m2



6.1.4) SERIAL WINGLET WING FENCE -

The model of serial winglet wing fence is classified into four different sections namely tip extension x velocity fence, y velocity fence, z velocity fence and k fence are shown in the below figure the black lines represent the tip extension model Trailing edge of tip extension starts from the trailing edge point on tip chord of main wing. Taper ratio parameter controls the tip chord of tip extension. The x, y, z velocity is travelling in the same path root chord velocity wing fence in serial winglet. the chord yellow epsilon and pink k fence are travelling in the different line way of chord the energy line blue fence way is standard it constant never change in the chord serial winglet and the continuity of black fence always flow higher than above every chord of fence in serial winglet.

FIGURE ;- DESIGN GRAPH



6.1.5) Serial winglet Wingtips

Wingtips are made of wooden material with specified dimensions assigned to the aerofoil of NACA 2412 SERIAL WINGLET as mentioned earlier, the leading edge of the tip section has greater sweep angle than the leading edge of main wing. In the model of serial winglet, the flow of lift is producing highly comparatively with other winglets model like single and parallel winglet Moreover the tip chord of serial winglet depends on taper ratio parameter. Also, the real parameter sweeps line length along with the tip chord of main wing controls the span of sweep line. The actual horizontal length of serial wing tip is given as an output parameter named “horizontal span serial” from the projected line. The parameters associated with serial wing tip were shown.

6.1.6) Prototype photos and explanation

Wingtips

Wingtips are made of wooden material with specified dimensions assigned to the aerofoil of NACA 2412. serial winglet as mentioned earlier, the leading edge of the tip section has greater wingtip angle than the leading edge of main wing. In below figure 1a and 2b, leading edge of serial winglet wingtip has been made in dependent with sweep reference line and sweep line. The sweep reference line shown in figure 2b represent the angle of sweep controlled by an angle parameter named sweep serial winglet. Moreover, the tip chord of serial wing tip depends on taper ratio parameter. Also, the real parameter sweeps line length along with the tip chord of main wing controls the span of sweep line. The actual horizontal length of tip is given as an output parameter named “horizontal span serial winglet” from the projected line. The parameters associated with serial wing tip were shown.



Fig fabrication



Fig testing of serial winglet (a)



Fig testing of serial winglet (b)

Chapter -7

7.1.1) NUMERICAL SIMULATION USING FLUENT RESULTS -

7.1.2) SINGLE WINGLET -

DRAG FORCE OF CD VALUE

Forces - Direction Vector (1 0 0)						
Forces (n)			Coefficients			
Zone	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-single_winglet	-214.12954	-27.260473	-241.39001	-0.0055935879	-0.0007121103	-0.0063056982
Net	-214.12954	-27.260473	-241.39001	-0.0055935879	-0.0007121103	-0.0063056982

LIFT FORCE OF CL VALUE

Forces - Direction Vector (0 1 0)						
Forces (n)			Coefficients			
Zone	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-single_winglet	-357.49074	207.41421	-150.07653	-0.0093385335	0.0054181671	-0.0039203664
Net	-357.49074	207.41421	-150.07653	-0.0093385335	0.0054181671	-0.0039203664

7.1.3) PARALLEL WINGLET-

DRAG FORCE OF CD VALUE

Forces - Direction Vector (1 0 0)						
Forces (n)			Coefficients			
Zone	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-parallel_winglets	-159.69918	-14.240345	-173.93953	-0.0041717338	-0.00037199268	-0.0045437265
Net	-159.69918	-14.240345	-173.93953	-0.0041717338	-0.00037199268	-0.0045437265

LIFT FORCE OF CL VALUE

Forces - Direction Vector (0 1 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-parallel_winglets	-13.854457	195.8985	182.04404	-0.00036191234	0.0051173486	0.0047554363
Net	-13.854457	195.8985	182.04404	-0.00036191234	0.0051173486	0.0047554363

7.1.4) SERIAL WINGLET; -

DRAG FORCE OF CD VALUE

Forces - Direction Vector (1 0 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-serial_winglets	-86.281695	0.20895245	-86.072742	-0.0022538892	5.4583498e-06	-0.0022484308
Net	-86.281695	0.20895245	-86.072742	-0.0022538892	5.4583498e-06	-0.0022484308

LIFT FORCE OF CL VALUE

Forces - Direction Vector (0 1 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-serial_winglets	167.05711	73.772603	240.82971	0.0043639408	0.0019271211	0.0062910619
Net	167.05711	73.772603	240.82971	0.0043639408	0.0019271211	0.0062910619

CHAPTER -8

8.1.1) RESULTS AND DIMENSIONS -

RESULTS AND DISCUSSION

There are three sets of results for the analysis of the problem. The results were obtained for the analysis of the variation of free stream velocity and for the determination of an efficient dimension set up of the shrouded wind turbine using 3D CFD models of wind turbine blades with varying the following shapes as follows

The parameter variations done are as follows.

Finally, when we compare the graphs of already existing model serial winglet and the Introduced model, we have found a big difference. It shows that the drag force of introduced model is greater than the existing model without the winglet and wingtip devices which is having a common aerofoil NACA 2412 which is the best lift producing device. The induced drags of both the models are as follows.

8.1.2)

A) Aerodynamic forces observation

{SINGLE WINGLET}

DRAG FORCE OF CD VALUE

Forces - Direction Vector (1 0 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-single_winglet	-214.12954	-27.260473	-241.39001	-0.0055935879	-0.0007121103	-0.0063056982
Net	-214.12954	-27.260473	-241.39001	-0.0055935879	-0.0007121103	-0.0063056982

LIFT FORCE AND CL VALUE

Forces - Direction Vector (0 1 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-single_winglet	-357.49074	207.41421	-150.07653	-0.0093385335	0.0054181671	-0.0039203664

Net	-357.49074	207.41421	-150.07653	-0.0093385335	0.0054181671	-0.0039203664

DRAG FORCE OF CD VALUE

FORCE PRESSURE =241.39001(D)

CO EFFICIENT PRESSURE = 0.0063056982(CD)

LIFT FORCE OF CL VALUE

FORCE PRESSURE = 150.07653 (L)

CO EFFICIENT PRESSURE = 0.0039203664(CL)

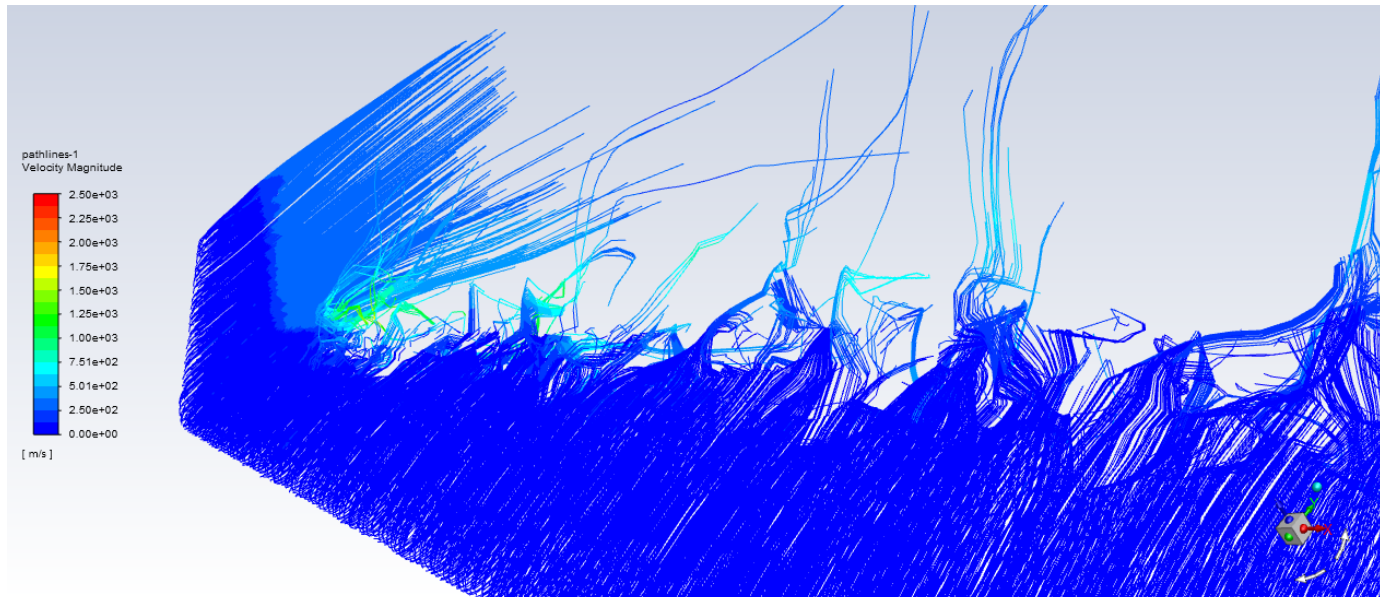
SINGLE WINGLET VALUES

L/D= 0.62171806530

CL/CD=0.6217180517

The below Figure gives the visualization of the turbulence intensity path lines that shows the changes in turbulence level at different areas in the flow field using different colours

8.1.3) Velocity observation



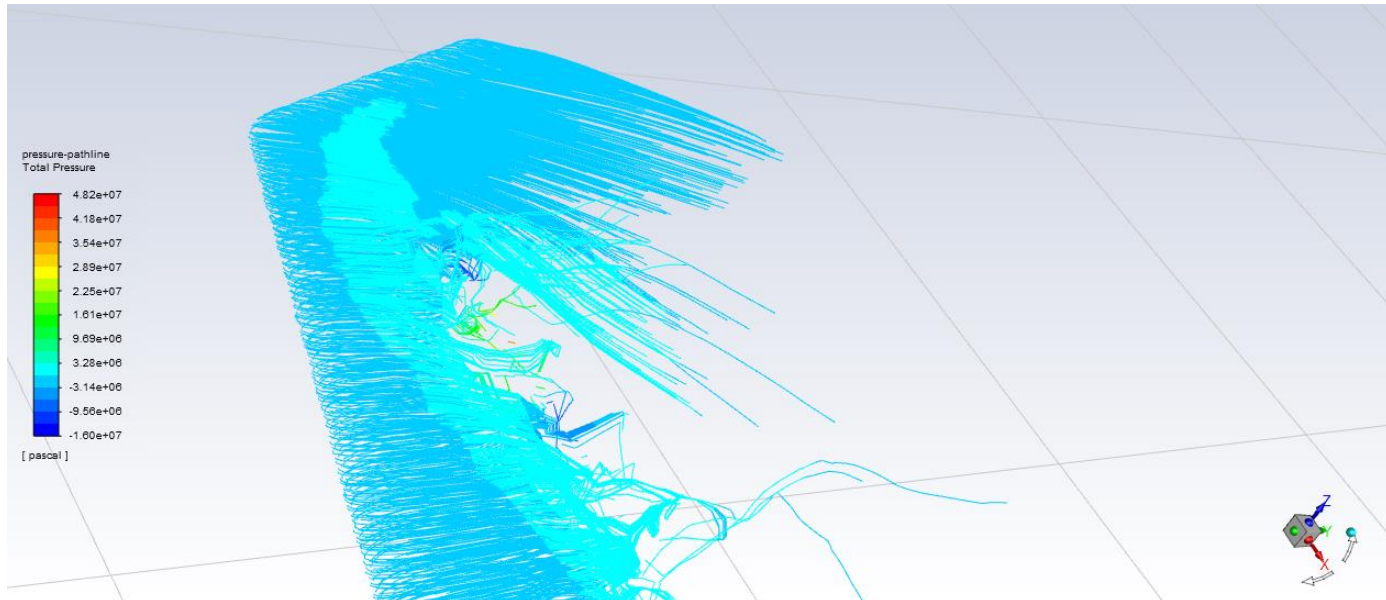
MAXIMUM VELOCITY = 2.50e+03

MINIMUM VELOCITY = 0.00e+00

IN BETWEEN VELOCITY=1.25e+03

8.1.4) Pressure observation

PRESSURE PATHLINES 1



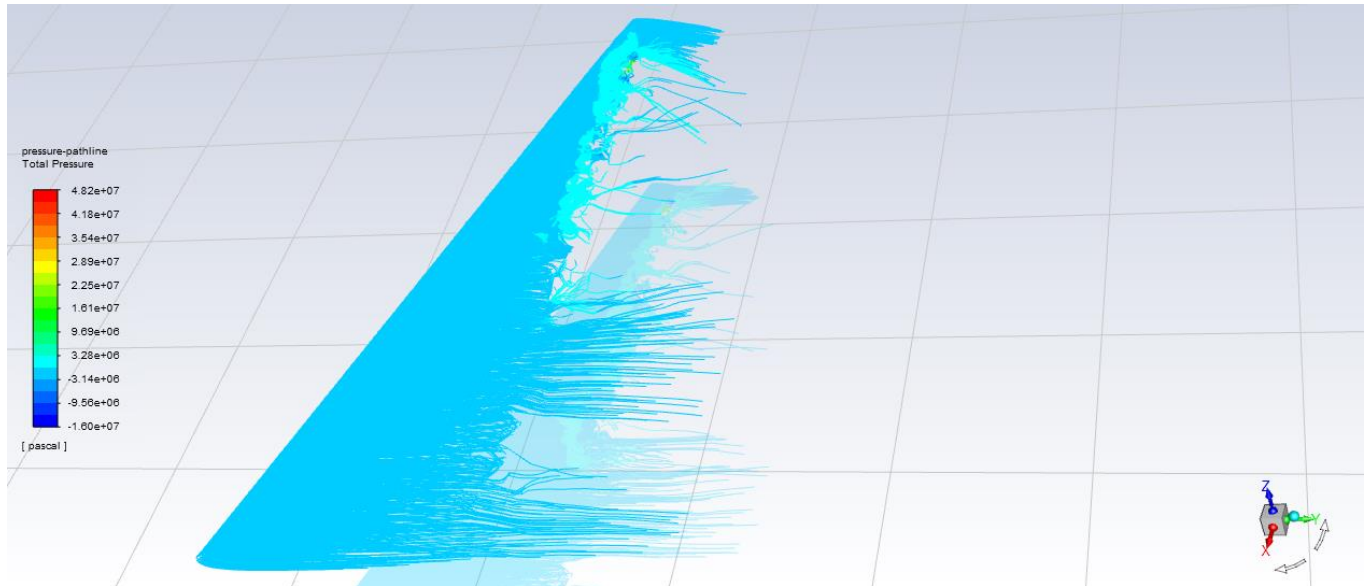
MAXIMUM VELOCITY = 4.82×10^7

MINIMUM VELOCITY = 1.60×10^7

IN BETWEEN VELOCITY = 1.61×10^7

Pressure observation-2

PRESSURE PATHLINES 2



8.1.5)

[PARALLEL WINGLETS]

a) Aerodynamic forces observation

DRAG FORCE AND CD VALUES

Forces - Direction Vector (1 0 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-parallel_winglets	-159.69918	-14.240345	-173.93953	-0.0041717338	-0.00037199268	-0.0045437265

Net	-159.69918	-14.240345	-173.93953	-0.0041717338	-0.00037199268	-0.0045437265

LIFT FORCE AND CL VALUES

Forces - Direction Vector (0 1 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-parallel_winglets	-13.854457	195.8985	182.04404	-0.00036191234	0.0051173486	0.0047554363

Net	-13.854457	195.8985	182.04404	-0.00036191234	0.0051173486	0.0047554363

DRAG FORCE OF CD VALUE

FORCE PRESSURE = 173.93953 (D)

CO EFFICIENT PRESSURE = 0.00454337265 (CD)

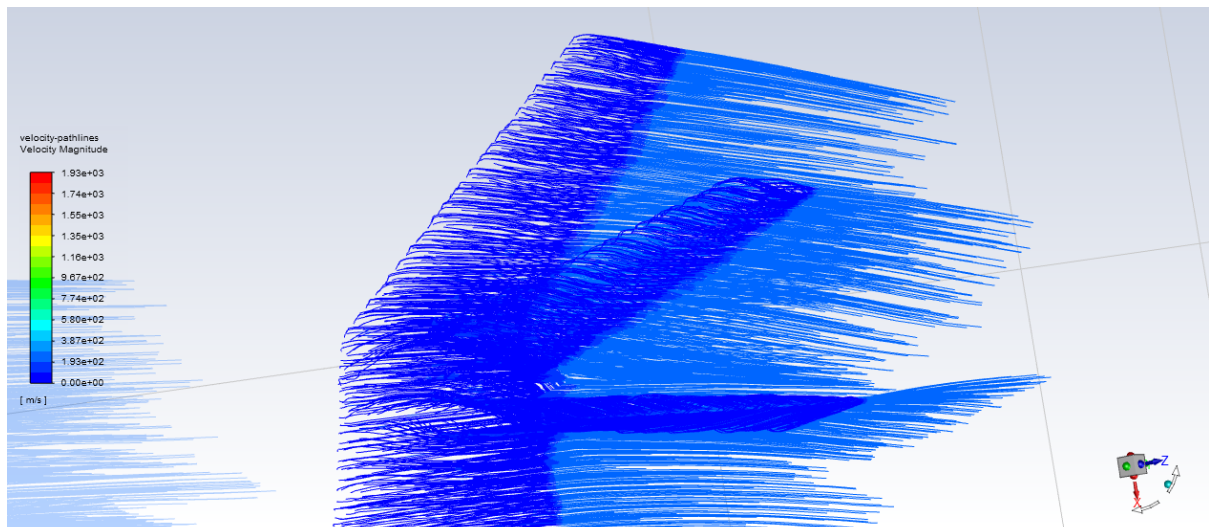
LIFT FORCE OF CL VALUE

FORCE PRESSURE = 182.04404 (L)

CO EFFICIENT PRESSURE = 0.0047554363 (CL)

8.1.6) Velocity observation

VELOCITY PATHLINES ON PARALLEL WINGLETS

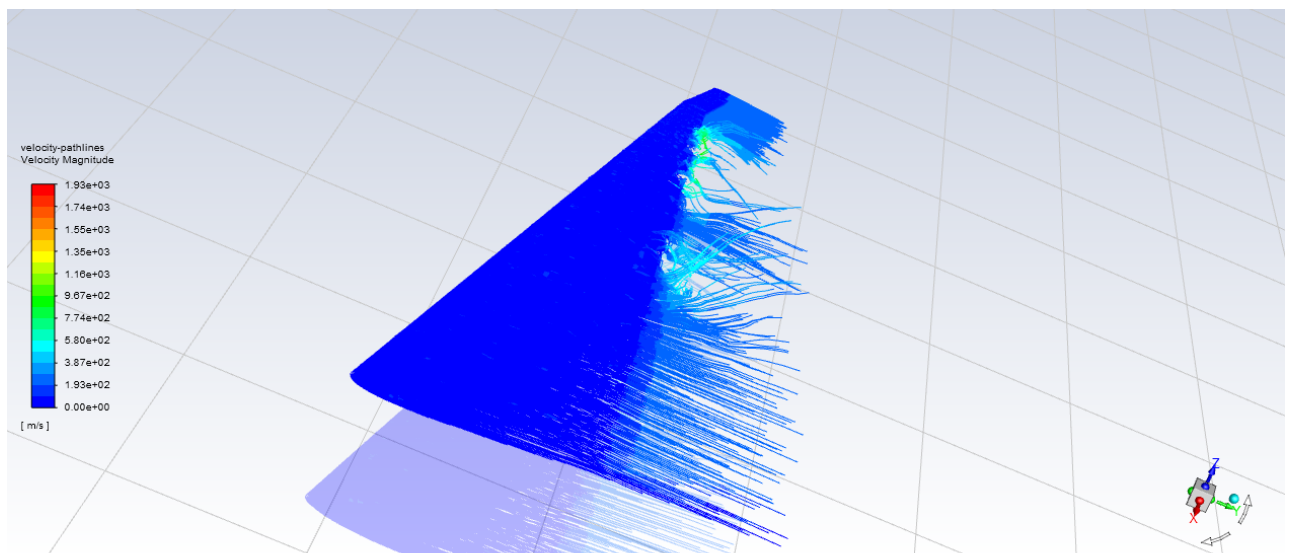


MAXIMUM VELOCITY 1.93e+03

MINIMUM VELOCITY 0.00e+00

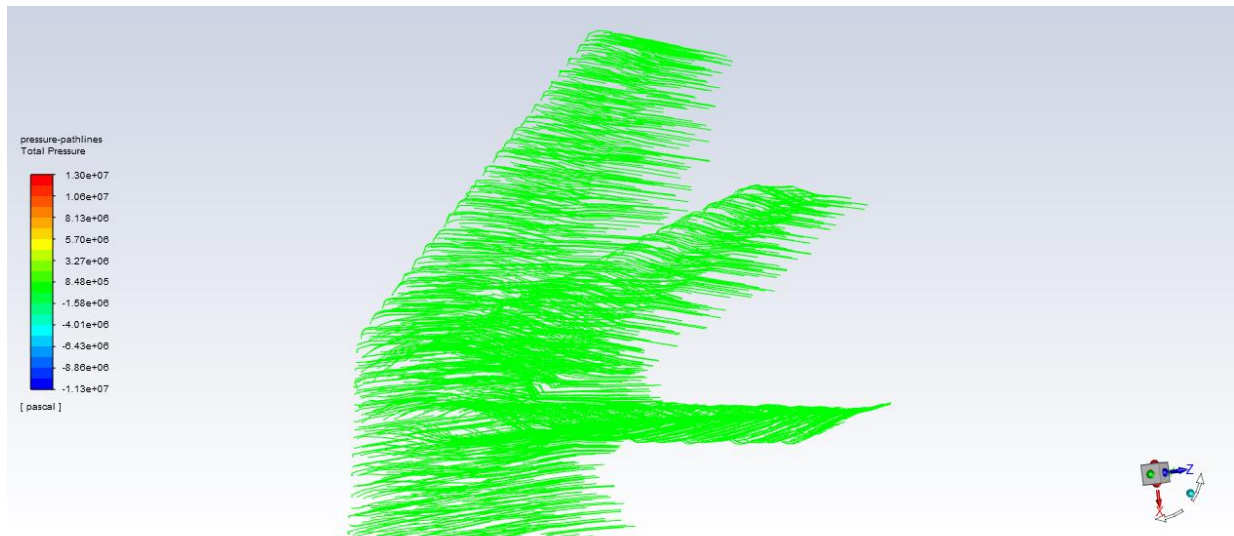
IN BETWEEN VELOCITY 9.67e+02

VELOCITY PATHLINES



8.1.7) Pressure observation

PRESSURE PATHLINES ON PARALLEL WINGLETS-1

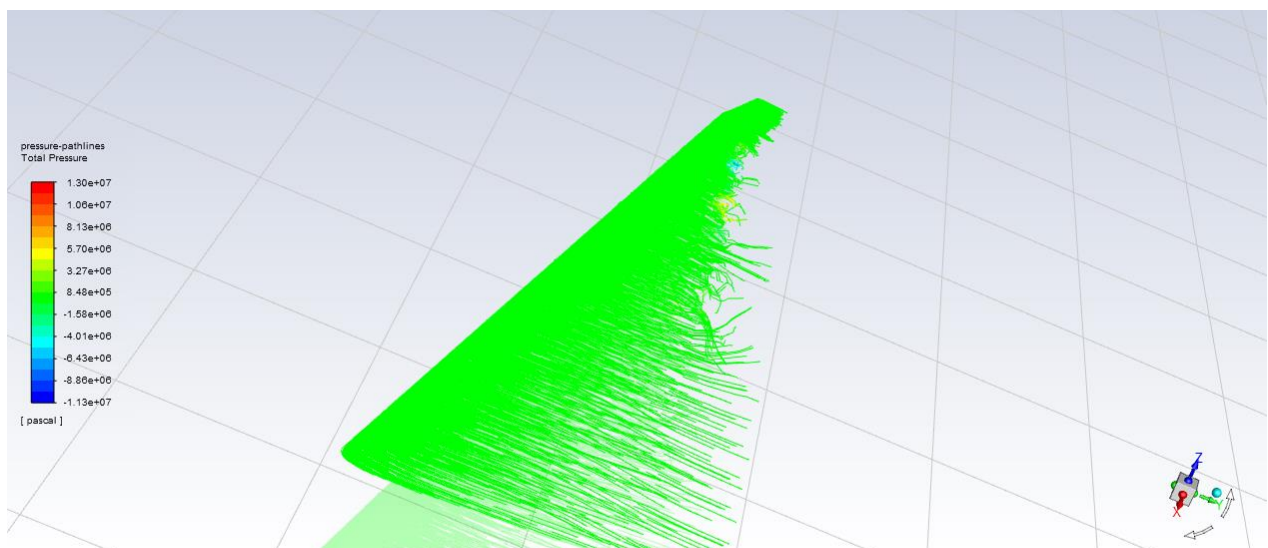


MAXIMUM VELOCITY 1.30×10^7

MINIMUM VELOCITY 1.3×10^7

IN BETWEEN VELOCITY 8.48×10^5

PRESSURE PATHLINES-2



8.1.8)

{SERIAL WINGLET}

a) Aerodynamic forces observation

DRAG FORCE AND CD VALUE

Forces - Direction Vector (1 0 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-serial_winglets	-86.281695	0.20895245	-86.072742	-0.0022538892	5.4583498e-06	-0.0022484308

Net	-86.281695	0.20895245	-86.072742	-0.0022538892	5.4583498e-06	-0.0022484308

LIFT FORCE AND CL VALUE

Forces - Direction Vector (0 1 0)						
Zone	Forces (n)			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
wall-serial_winglets	167.05711	73.772603	240.82971	0.0043639408	0.0019271211	0.0062910619

Net	167.05711	73.772603	240.82971	0.0043639408	0.0019271211	0.0062910619

DRAG FORCE OF CD VALUE =

FORCE PRESSURE = 86.072742 (D)

CO EFFICIENT PRESSURE = 0.0022484308 (CD)

LIFT FORCE OF CL VALUE =

FORCE PRESSURE = 240.82971 (L)

CO EFFICIENT PRESSURE = 0.0062910619 (CL)

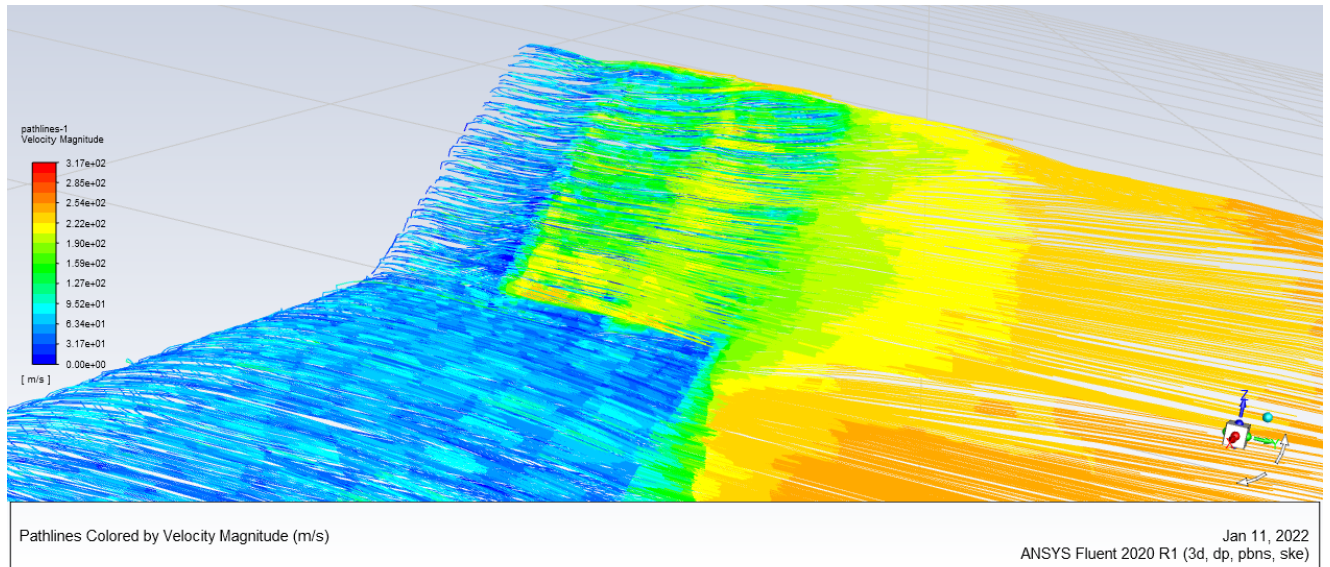
SERIAL WINGLET VALUES =

L/D= 2.797978830

CL/CD=2.797978883

8.1.9) Velocity observation

VELOCITY PATHLINES



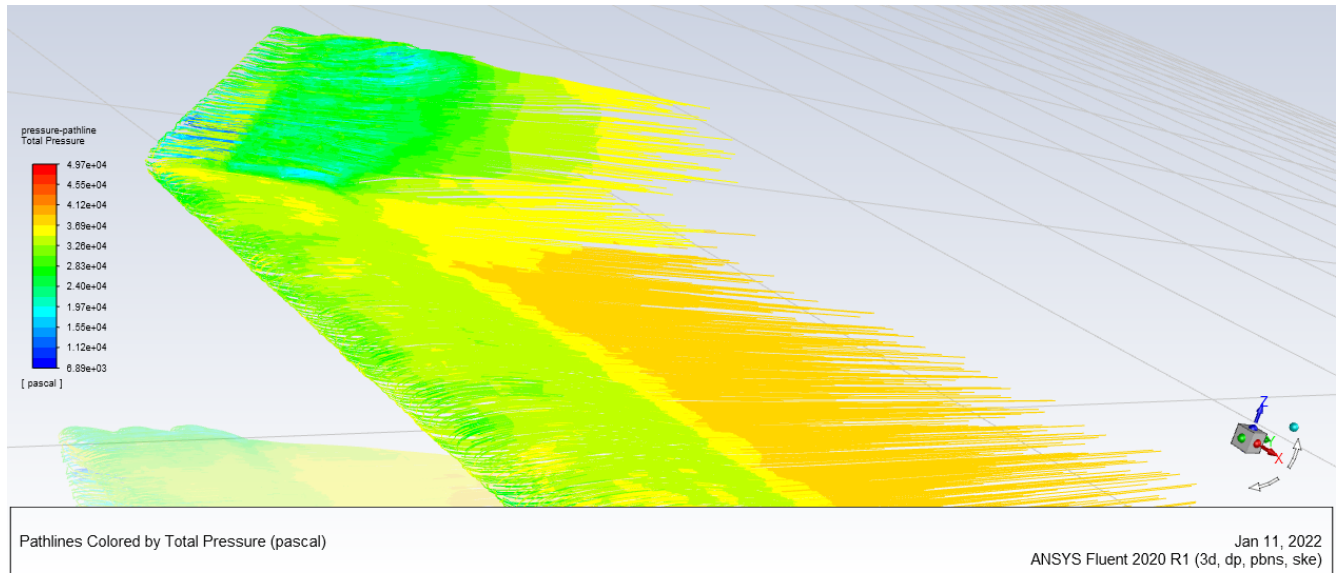
MAXIMUM VELOCITY 3.17e+02

MINIMUM VELOCITY 0.00e+00

IN BETWEEN VELOCITY 1.59e+02

8.2.0) Pressure observation

PRESSURE PATHLINES-1

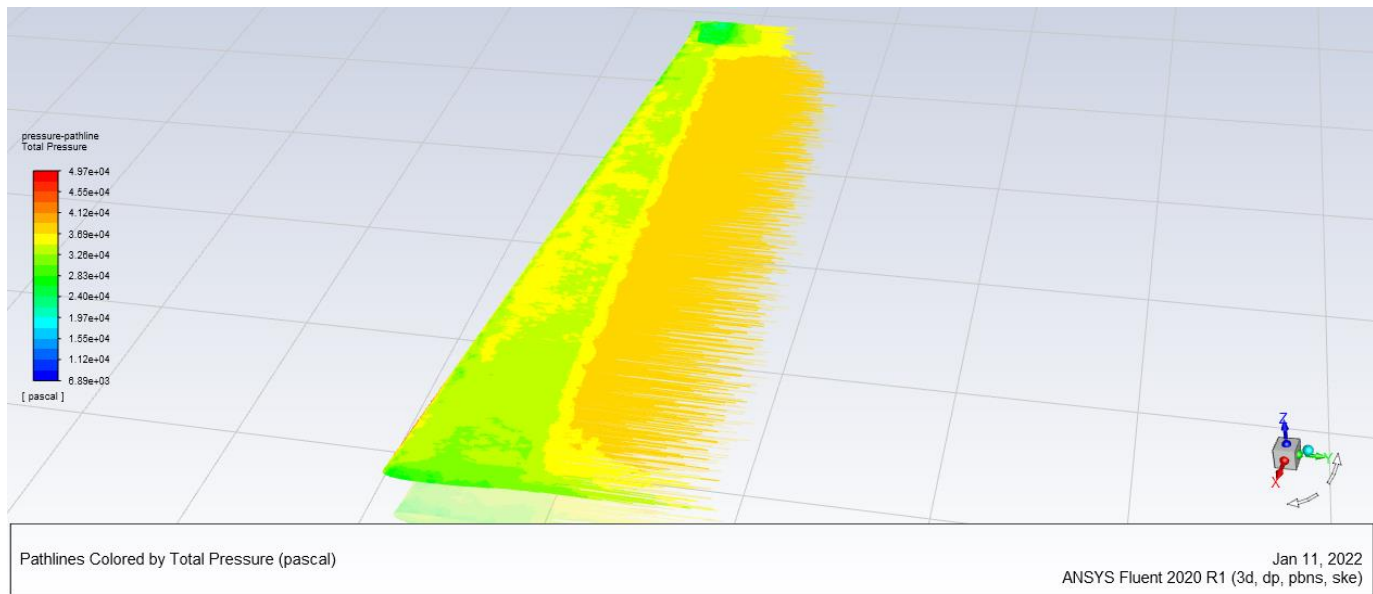


MAXIMUM VELOCITY 4.97e+04

MINIMUM VELOCITY 6.89e+03

IN BETWEEN VELOCITY 2.83e+04

PRESSURE PATHLINES 2



8.2.1)

Comparison of the values for All winglets

Blade Type	Lift (N)	Drag (N)	Cl	Cd	Aerodynamic efficiency(η)	Cl/Cd
Single winglet	150.07653	241.39001	0.0039203664	0.0063056982	0.62171	0.62171
Parallel winglet	182.04404	173.93953	0.0047554363	0.0045437265	1.04659	1.04659
Serial winglet	240.82971	86.072742	0.0062910619	0.0022484308	2.79797	2.79797

Finally, when we compare the graphs of already existing model serial winglet and the Introduced model, we have found a big difference. It shows that the drag force of introduced model is greater than the existing model without the winglet and wingtip devices which is having a common aerofoil NACA 2412, which is the best lift producing device. The induced drags of both the models are as follows.

($L/D=LIFT /DRAG$) ($CL/CD=COEFFICIENT OF LIFT /COEFFICIENT OF DRAG$)

SINGLE WINGLET

$L/D= 0.62171806530$

$CL/CD=0.6217180517$

SERIAL WINGLET

$L/D= 2.797978830$

$CL/CD=2.797978883$

PARALLEL WINGLET

$$L/D=1.046593836$$

$$CL/CD=1.046593869$$

The drag force graph for existing model serial winglet clearly gives the less drag with best lift that is being able to produce. Similarly,

**THE BEST OF AMONG THREE WINGLETS IS SERIAL WINGLET
WHICH HAVE MORE LIFT / DRAG VALUE (2.797978830)**

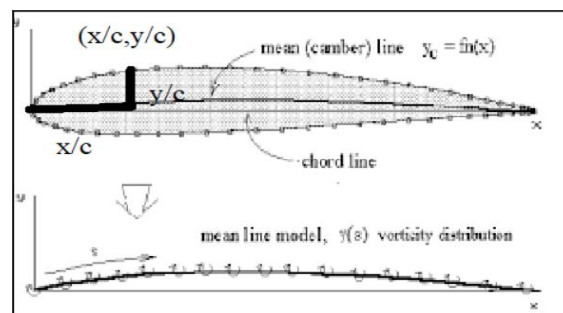
8.2.2) EXPERIMENTAL CALCULATION SERIAL WINGLET

8.2.3) EXCEL CALCULATION CL AND CD

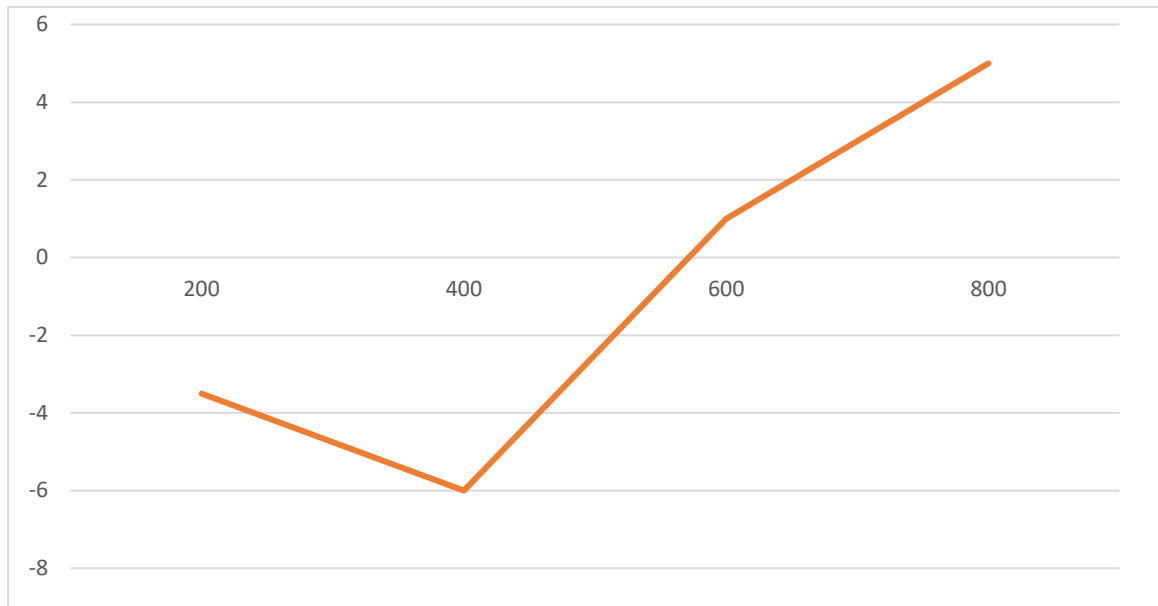
RPM PORTS	200	400	600	800
1	1.4	1.2	1.6	1.8
2	1.8	2.9	5	8.1
3	1.5	1.7	2.1	2.9
4	1.8	3.5	5.6	8
5	1.8	3.6	6	9
6	1.6	2.7	4.5	6.7
7	1.4	2.9	7.4	11.5
8	1.5	2	3.8	6.1
9	1.8	3	5.1	8.3
10	1.7	2.9	5.1	8
11	1.4	1.4	1.4	1.5
12	1.4	1.7	2.3	3.4

x/c	200	400	600	800
CL/CD COEFFICIENT OF LIFT / COEFFICIENT OF DRAG				
CL	-0.25	0.5	-0.36	-0.35
CD	-0.05	0.5	0.06	0.097
l/d	5	1	-6	-3.5

calculate x/c and y/c for each port location



GRAPH



$Cl = (\text{max value upper chamber} - \text{min value lower camber}) * (x/c \text{ max} - x/c \text{ min})$

$Cd = (\text{max value upper chamber} - \text{min value lower camber}) * (y/c \text{ max} - y/c \text{ min})$

sample x/c

but you have to calculate x/c and y/c for your air foil model.

choose only negative value max and min for calculating cl and cd

8.2.4) EXPERIMENTAL CALCULATION SERIAL WINGLET

8.2.5) ANGLE OF ATTACK

EXCEL CALCULATION AOA

4deg 6deg 8deg 10deg 12deg 15deg

-1.7	-1.4	1.4	-1.3	-1.4	-1.6
4.1	4.2	3.9	3.9	4.1	4.1
-1.3	-0.9	-1.1	-0.9	-1.4	-1.4
4	3	2.8	2.1	2.7	2.7
5.2	3.1	3.3	-0.2	2.9	3.2
2.3	1.2	1.3	-0.1	0.2	0.8
-0.1	4.6	4.4	4.8	0.1	4.3
3.7	3	3.1	3.1	3.1	3.2
4.3	4	3.7	4.8	4.6	4
4.6	4.6	4.6	4.8	4.7	4.6
-1.9	-1.9	-1.9	-1.9	-1.9	-1.9
-1.2	-0.7	-0.8	-0.8	1	-1

RPM -800

2

4

6

8

10

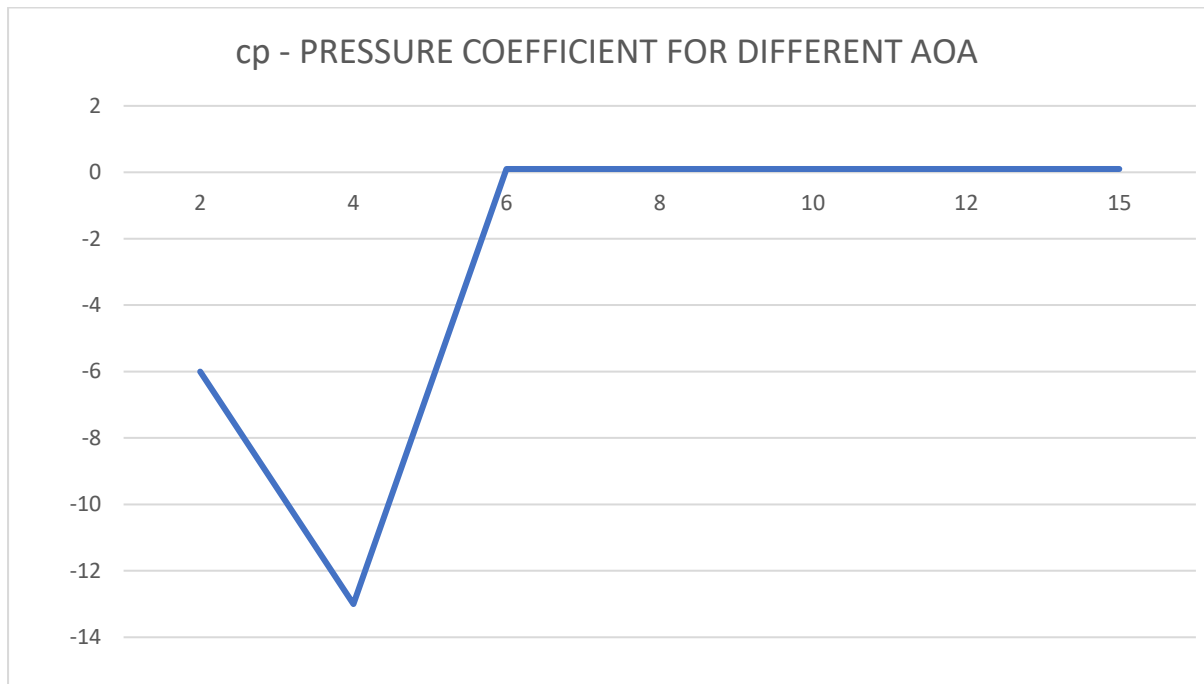
12

15

cp - PRESSURE COEFFICIENT FOR DIFFERENT AOA

CL	0.12	0.06	0.1	0.08	0.648	-0.065	0.05
CD	1.2	0.6	1	0.8	-0.108	0.0005	0.5
TOTAL	0.1	0.1	0.1	0.1	-6	-13	0.1

GRAPH



$Cl = (\text{max value upper chamber} - \text{min value lower camber}) * (x/c \text{ max} - x/c \text{ min})$

$Cd = (\text{max value upper chamber} - \text{min value lower camber}) * (y/c \text{ max} - y/c \text{ min})$

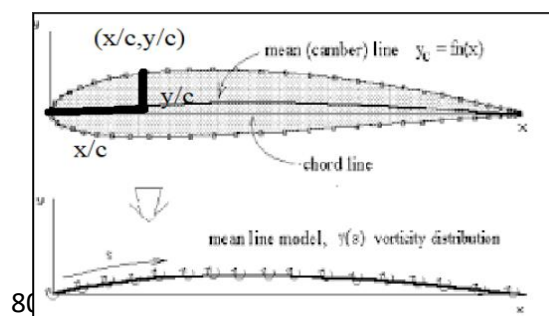
sample x/c

but you have to calculate x/c and y/c

for your air foil model.

choose only negative value max and

min for calculating cl and cd



8.2.6)

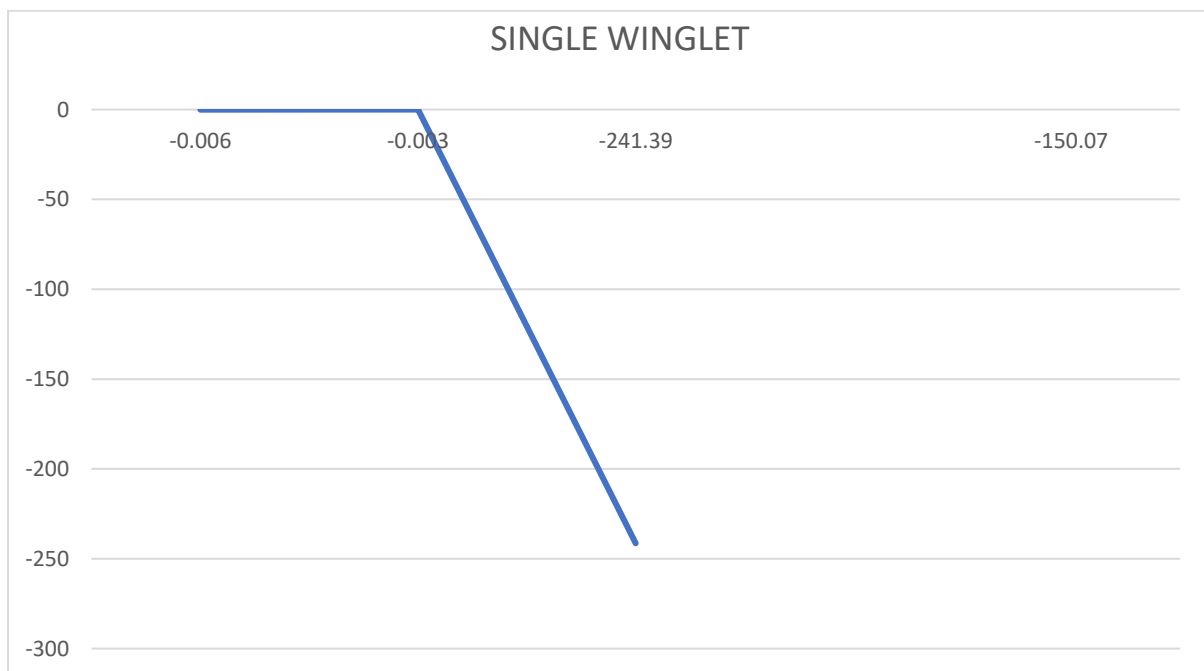
NUMERICAL SIMULATION VALUE FOR ALL THREE WINGLETS WITH GRAPH

8.2.7)

SINGLE WINGLET

	CD	CL		
	VALUE	VALUE	FORCEPRESSURE(D)	FORCEPRESSURE(L)
VALUES	-0.006	-0.003	-241.39	-150.07
TOTAL CL/CD		0.621		
TOTAL L/D		0.621		

GRAPH

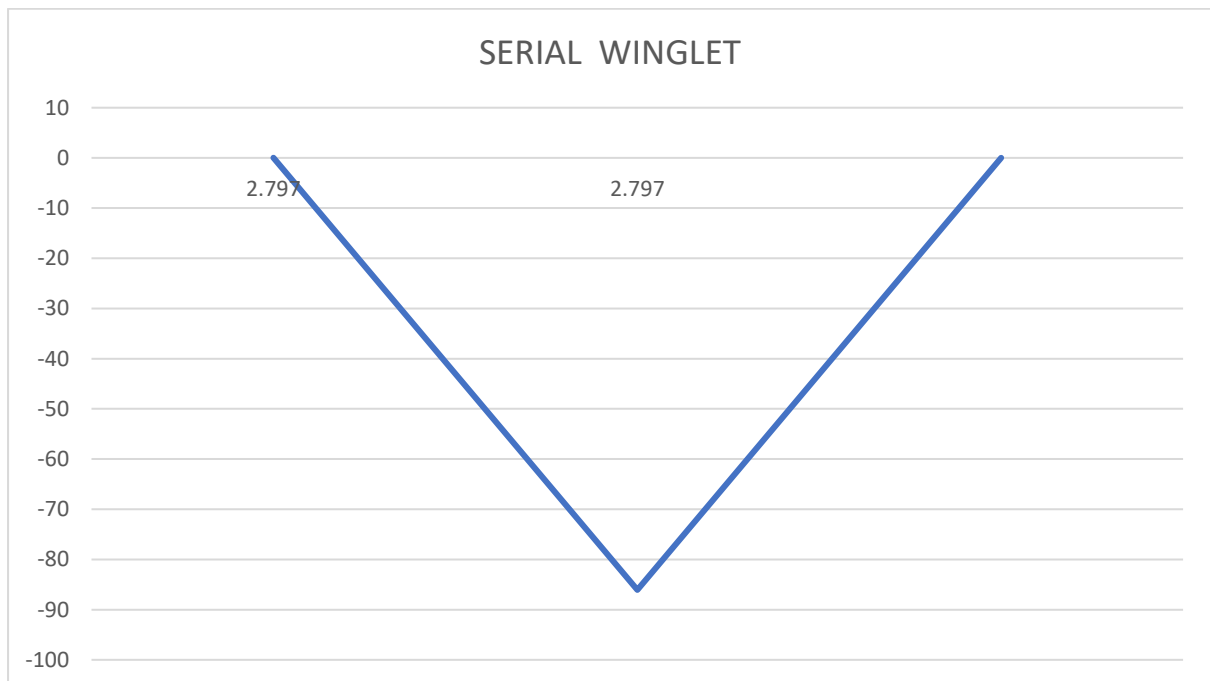


8.2.8)

SERIALWINGLET

	CD	CL	FORCEPRESSURE(	FORCEPRESSURE(
VALUES	VALUE	VALUE	D)	L)
	-0.002	0.006	-86.07	240.82
TOTAL CL/CD		2.797		
TOTAL L/D		2.797		

GRAPH



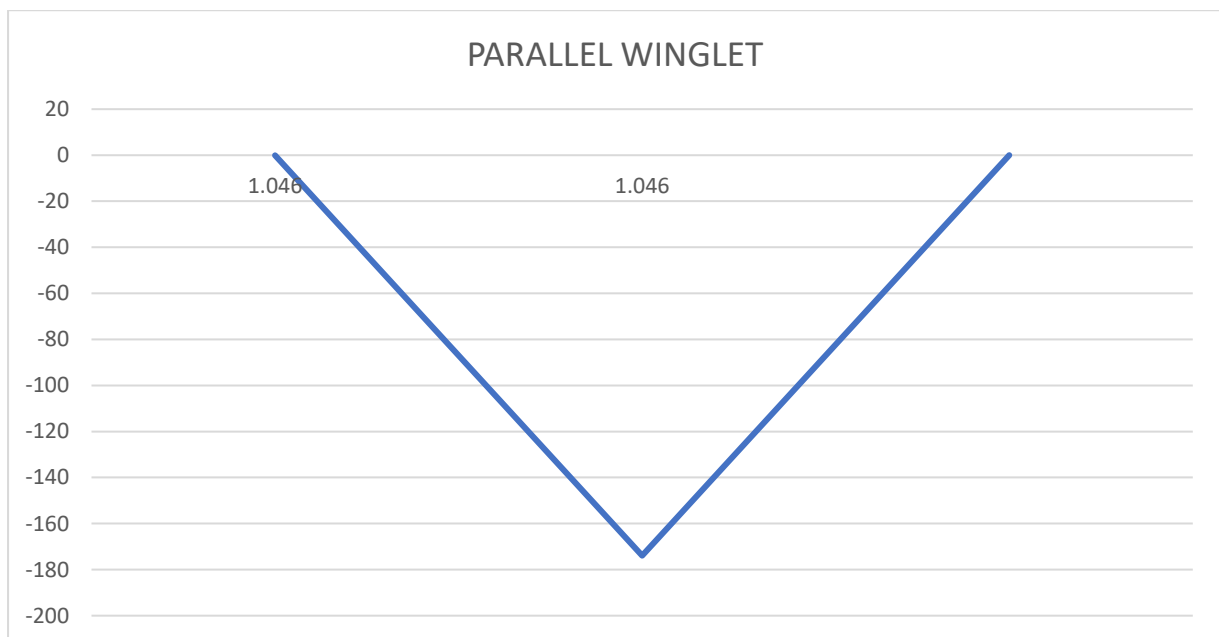
8.2.9)

PARALLELWINGL

ET

	CD VALUE	CL VALUE	FORCEPRESSURE(D)	FORCEPRESSURE(L)
VALU E	-0.004	0.004	-173.93	182.044
TOTAL CL/CD	1.046			
TOTAL L/D	1.046			

GRAPH



8.3.0)

COMPARISON GRAPH FOR CL/CD AND AOA(α)

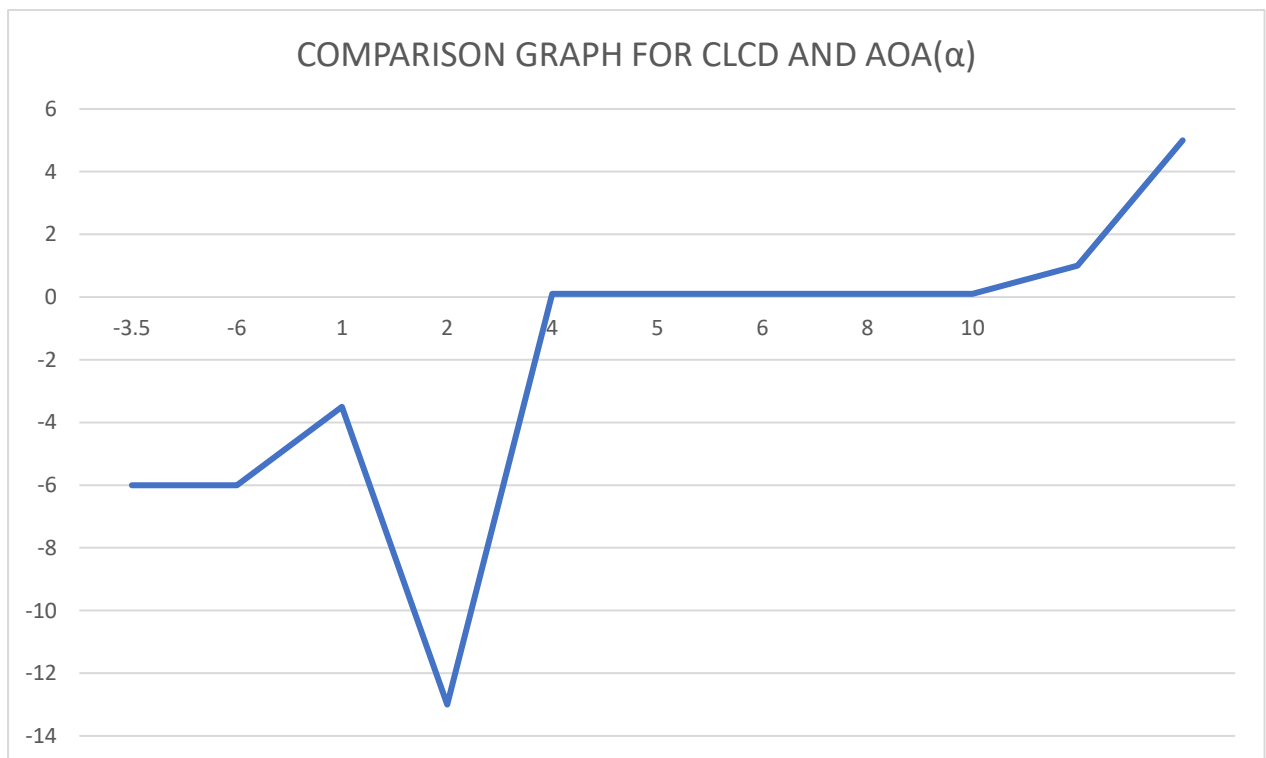
l/d 5 1 -6 -3.5

RPM 200 400 600 800

DEG 2 4 6 8 10 12 15

L/D 0.1 0.1 0.1 0.1 -6 -13 0.1

GRAPH



8.3.1) LOSS PERCENTAGE CALCULATION RESULT

the loss percentage of the experimental value and numerical value are calculated so, the accuracy occurred in this experimental project = 1.775

nearly overall 60 percentage it performed in this project

9.0 CHAPTER 9

9.1.1) Conclusion

Various sorts of winglets and tip gadgets have been considered and furthermore their part in the airplane industry is examined in this work. Diminishing generally haul in an airplane is conceivable with the help of winglets. Adding winglets to airplane wing give an increment in angle proportion which is one of the principal factors for decreasing instigated drag. Also, the idea of instigated drag is considered and its commitment in the general airplane execution is determined. All the counts made are through an applied methodology for example by applying straightforward recipe and no refined strategies are utilized. In view of the aftereffects of incited drag computation and departure execution figuring, an extra weight for each drag tally decrease is distinguished. Aircraft administrators could have an additional traveller/payload for a similar take-off field length, which is one of the reality benefits for them. Additionally, every traveller represents extra pay for the administrator and this is one of the primary explanations for the establishment of the winglet. From the streamlined viewpoint, winglets would decrease the prompted haul regardless of expanding the parasite drag. Upgrading the size of the winglets could evade the extraordinary increment of frictional drag, consequently diminishing generally speaking drag at bargaining level. Then again, by understanding the meaning of winglets to an airplane, mechanized conventional models of winglet are planned

primarily zeroing in on diminishing the plan time. Besides, Knowledge Pattern approach and its highlights are utilized for the launches. The model of primary wing where the parametric model to be launched ought to be named as referenced in UDFs. Additionally, the air foil to be utilized in the winglet would likewise be subject to the tip air foil of the primary wing. Pre-launch work must be done prior to picking the number of mix boards if there should be an occurrence of mixed winglet type. The skeleton of the mixed vertical ought to be changed prior to launching the boards to get the ideal shape and this applies to every one of the models aside from tip gadgets. The mechanization work is accomplished in this work dependent on Information Pattern just and no VBA approach is utilized. Consequently, no time examination investigation is performed thus an ideal opportunity for every launch isn't noticed. Conventional model created could take various shapes and sizes with the assistance related boundaries and could be utilized in the pre-plan phase of winglets, where investing more energy in the plan cycle can be limited. All the winglets created in this work are planned concurring with the plan measures given by the individual patent holders thus there will be no requirement for planning a particular sort of winglet from the base, when this model has been utilized.

9.1.2) REFERENCE BOOKS

1. S. A. Kravchenko, "The application of the wingtip lifting surfaces for practical aerodynamic," in ICAS, 1338-1349, 2015
2. R. T. Whitcomb, "A design approach and selected wind-tunnel results at high subsonic speeds for wing-tip mounted winglets," tech. rep., NASA TN-D-8260, 2015
3. J. J. SPILLMAN, "THE USE OF WING TIP SAILS TO REDUCE VORTEX DRAG," AERONAUTICAL JOURNAL, VOL. 82, PP. 387–395, 2016
4. J. J. Spillman and M. McVie, "Wing tip sails which give lower drag at all normal flight speeds," Aeronautical Journal, vol. 88, pp. 362– 369, 2016
5. J. J. Spillman, "Wing tip sails; progress to date and future developments. aeronautical journal, vol 91 no 9xx, pp 445-543, 1987.," Aeronautical Journal, vol. 91, pp. 445–543, 2016
- 6 M. J. Smith, N. Komerath, R. Ames, O. Wong, and J. Pearson, "Performance analysis of a wing with multiple winglets," in AIAA Applied Aerodynamics, AIAA 2001-2407, 2017

7 H. H. Hyson, et al., "Theoretical Parametric Study of the Relative Advantages of Winglets and Wing-tip Extension," NASA Langley Research Centre, Virginia 2013.

8. J. E. Guerrero, et al., "Biomimetic spiroid winglets for lift and drag control," *Comptes Rendus Mécanique*, vol. 340, pp. 67-80, 2012.

9. L. R. Jenkinson, et al., *Civil jet aircraft design* vol. 7: Arnold London, 1999.

10. P. Thiede, *Aerodynamic Drag Reduction Technologies: Proceedings of the CEAS/Dragnet European Drag Reduction Conference, 19-21 June 2000, Potsdam, Germany* vol. 76: Springer Verlag, 2001.

11. D. McLean, "Wingtip Devices: What they Do and How They Do it," presented at the Boeing Performance and Flight Operations Engineering Conference 2005.

