**NUMERICAL INVESTIGATION OVER NACA 4412 AIRFOIL**

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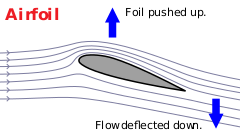
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**Abstract** – The study of flow over Airfoil is engrossed since the late 19’s century due to the versatile effect of achieving aerodynamic efficiency. The airfoil is designed to create pressure difference over its area due to which Non-Dimensional LIFT and Drag forces create. The present study is a CFD investigation over NACA 4412 Airfoil up to Stall Effect. The CFD investigation is validated over Experimental Data. The correlation of vortices with increasing lift and drag coefficient is also suggesting in the present investigation.

***Keywords- Airfoil, CFD, NACA4412, Stall, Validation, Vortices.***

# **1. Introduction**

The Flow around the aircraft causes the creation of pressure difference in the airfoil cross-section due to which the creation of lift takes place. Similar to a bird an Aircrafts are tended to take a lift in the air due to the creation of pressure difference on the airfoil cross-section. An airfoil crosssection is Curved in the surface from which fluids tend to be directed in motion, The cross-sections are designed in a manner to tends in giving the most Lift-Drag ratio in flight. The fluid which tends to flow around the surface area of foil causes the creation of an Aerodynamic effect in which the perpendicular region is called Lift and Components parallel to direction is called the creation of Drag, as shown in figure 1.



**Figure 1. Aerodynamic forces components.**

The creation of aerodynamic forces is purely dependent on the flow of direction and Angle of attack of the airfoil towards airflow. Recent research is carried out to understand the changing creation of aerodynamic forces according to the working condition, [1] An Eppler E387 low Reynolds number airfoil, has been validated over CFD data for the increasing angle of attack and changing grid parameter [2] A comparative analysis between Cl and d has proposed to validate results numerically and experimentally in which it suggests that highly cambered airfoil gives more instantaneous lift. [3]In this study, two airfoils are used and their drag estimation is performed with the improved formulation. The airfoil with the improved formulation showed the drag accurately with the small trailing edge thickness. [4] The air bubble when strikes the leading edge of the airfoil it separates into two which are called separation bubble characteristics, so in this study, the lift and separation bubble characteristic of a NACA18 airfoil is validated. [5] In this study, the flow structure of the NACA 0012 airfoil is investigated at the leading edge under the dynamic stalling conditions using a theory called planar particle image Velocimetry. [6] In this study, the NACA 0012 to airfoil is being used to validate the modification to Ohio state 6\*22 transonic wind tunnel to enable modulation of the free-stream Mach number. [7] In this study, they have investigated the effects of erosion using CFD at the leading edge and semi-circle cavities and the pitting erosion on the foil. [8] In this study, NACA 0012 airfoil was used to investigate lift drag and surface pressure. This study consists of full range static polar and various dynamic sinusoidal pitching configurations using 2 Reynolds numbers that are 140k and 180k. [9]In this study, NACA 4412 airfoil is used. The validation is performed to overcome the large eddy simulation and detach eddy simulation which are the inaccuracies of the higher turbulence model. [10] In this study, NACA 0012 airfoil is used to perform unsteady numerical simulations for the various angle of attack for the Reynolds number 5.0\*10^5 and 1.8\*10^6. The study is performed to guide the creation of computational cells for the calculations. [11] The airfoil used in this study is the NASA low speed GA (W)-1 airfoil to characterize the transient behavior at a Reynolds number of 70,000. It was found that the laminar separation bubble was found to move upstream with the increase in the angle of attack. After this formation of the separation bubble on the airfoil, it was found that the increased rate of life coefficient was degrading and the drag coefficient increased as with the increase in the angle of attack and at last, the separation bubble was busted causing the airfoil to stall when the angle of attack was less than 12.0 degree. [12] In this paper, the study of S890 airfoil is done in which the effect of periodic excitation with the help of synthetic jet actuators is done within the separation and reattachment regions of the boundary layer. After performing the validation results show that the periodic excitation which is produced by the jet actuators eliminates the laminar separation bubble. Which is formed over the suction surface of the airfoil. [13] In this paper, the S809 airfoil is used and flow separation control has been performed using synthetic jet technology and after the validation, lift to drag ratio has been considered by the synthetic jet and then compared to single synthetic jet double jets can make much better improvement on flow separation control of airfoil. [14] NACA 4412 airfoil is being used to validate the aerodynamic performance by incorporating the curvature at the leading edge of the airfoil and after the validation, the results were found out to be having a higher lift coefficient and lower drag coefficient than the rectangular wing platform. [15] The results obtained from this study show that numerically solving flow problems using the numerical investigation is a valid scheme since it proposed results more pressies as per the real-life scenario.

## **1.1 Problem statement description**

The present research work is based on Computational CFD Validation over theoretical CFD for NACA 4412 Airfoil on different Angle of attack at 0.75 Mac Rate.

# **2. Numerical Method and Mesh**

The present work is carried out using Commercial coded Ansys Fluent software. In the present work, a free field velocity inlet is kept as 275 M/S which is 0.75 Mach. The parametric Reynolds number calculated as 1.7374e+7 for a Chord length of 1 Meter. The taken parameter is as shown below in table 1. The formation of the Grid is shown in figure 1. The equation for calculating the Angle of Attack is shown below.

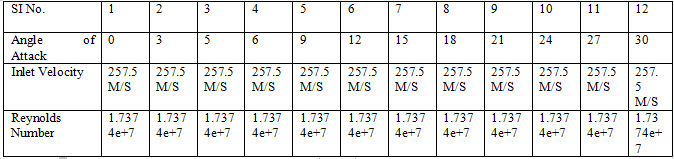
α = θ –γ (1) **Table1** Parameters used in the numerical simulation.



Figure 2. Grid formation

**2.1 Numerical Scheme**

The present investigation is carried using the Turbulence model of K-Epsilon because the kinetic desperation value of Epsilon works better with the inlet flow of higher Reynolds number. In the present case, the inlet velocity is up to 0.75 Mach which is investigated over Non-deformable Mesh structure in increasing Angle of attack over NACA 4412 Airfoil. The equation shows the Turbulence modeling of K-Epsilon

The turbulent energy k is given by:

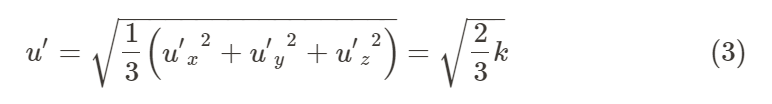
(1) k=32(UI)2

where U is the mean flow velocity and I is the turbulence intensity.

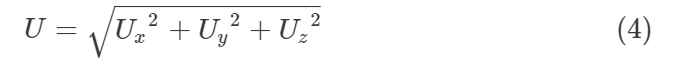
The turbulence intensity gives the level of turbulence and can be defined as follows:

(2) I=u′/U

where u′ is the root-mean-square of the turbulent velocity fluctuations given as:

 (3)

The mean velocity U can be calculated as

follows:

(4)

The turbulent dissipation rate can be calculated using the following formula:

  
(5)

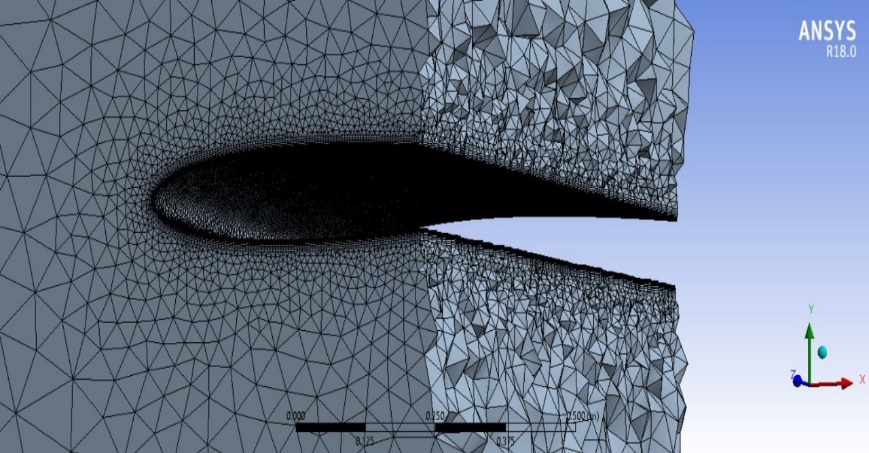
Where Cμ is the turbulence model constant which usually takes the value 0.09, k is the turbulent energy, l is the turbulent length scale.

The turbulence length scale describes the size of large energy-containing eddies in a turbulent flow.

The turbulent viscosity νt is, thus, calculated as:

(6) Vt = 0.09

**2.2 Mesh Formation**

The Fine refinement of meshing is carried out over NACA 4412 Airfoil with the formation of a Square Grid. The Manual refinement of 3 around the peripheral boundary of Airfoil is carried out to capture more refine finite volume chunks over Airfoil. The information layer of 120 components is given over the airfoil.

REFINEMENT LAYER

Figure 3. Refinement Layer

# **3. Results and Discussion**

## **3.1 Results**

The cases are investigated as shown in table 1. Where the inlet velocity is kept is 257 m/s and increment on Angle of attack is done from 0 to 30 with an instance of 3 Degree. The below Figure shows below the results of the increasing angle of attack.

### Case 1) 0 Degree AoA.

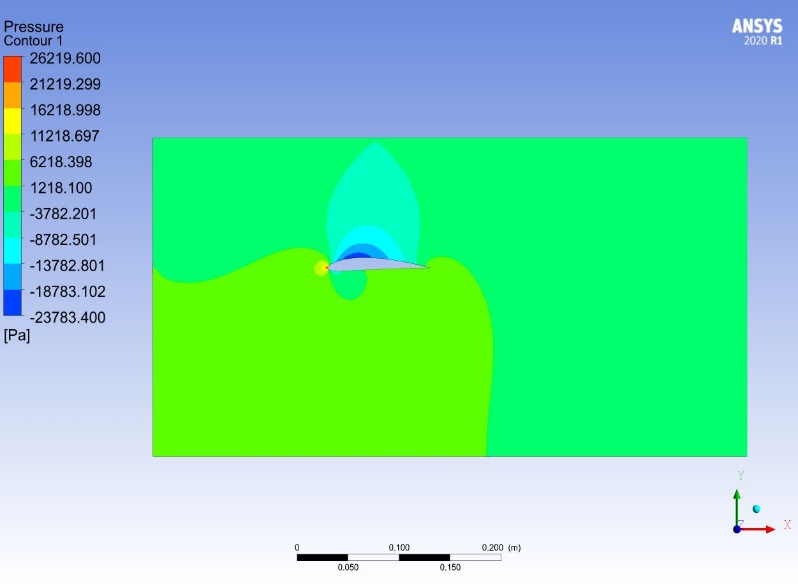
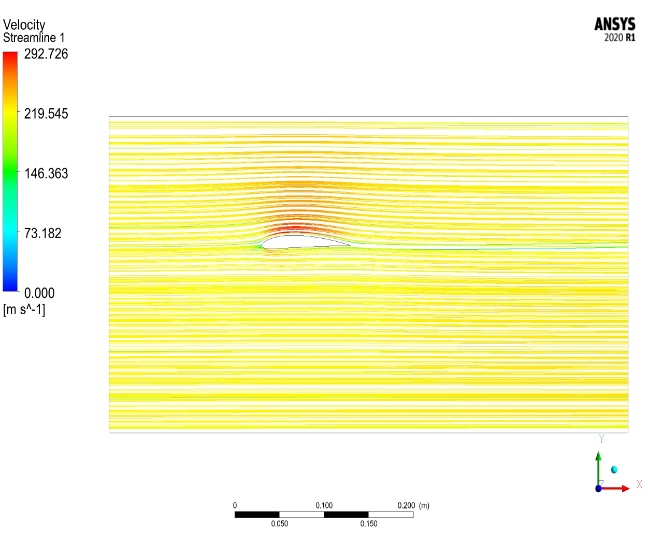
 

Figure 4. Pressure and Velocity Contour

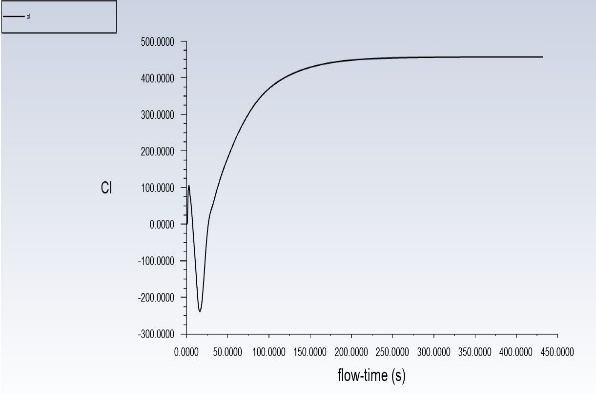
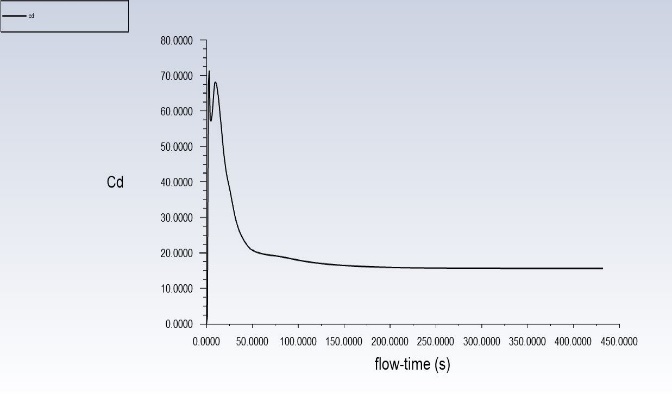


Figure 5. Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

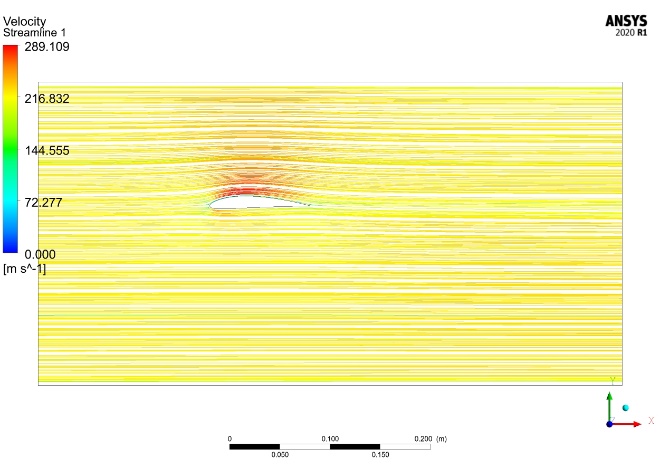
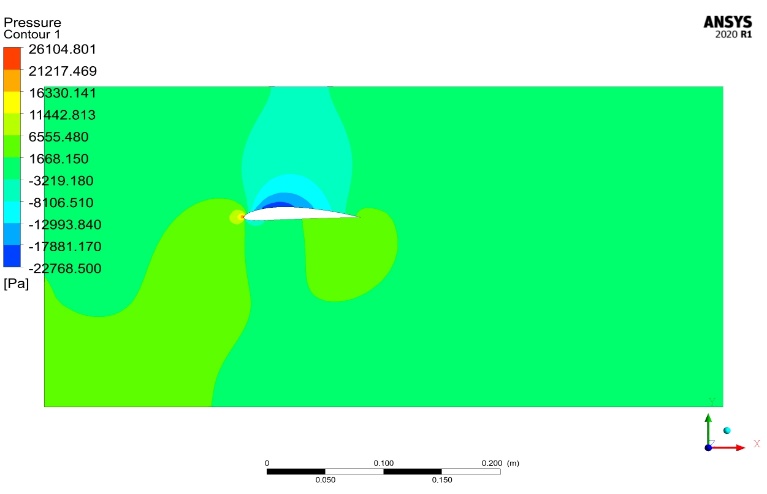
Case 2) 3 Degree Angle of Attack.

Figure 6 Pressure and Velocity Contour

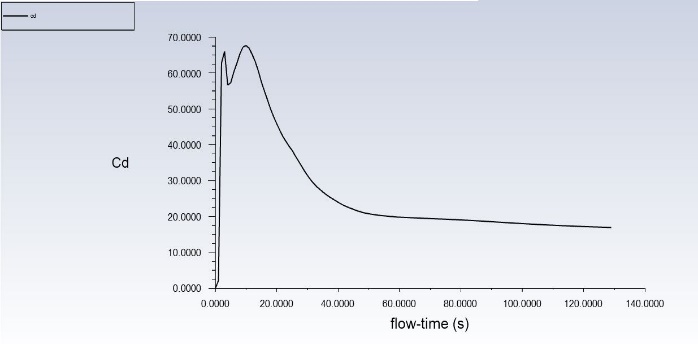
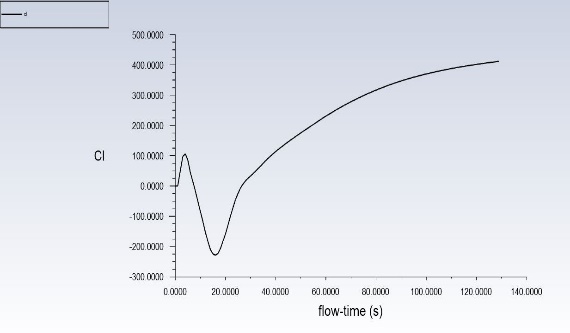
 

Figure 7 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 3) 5 Degree Angle of Attack.

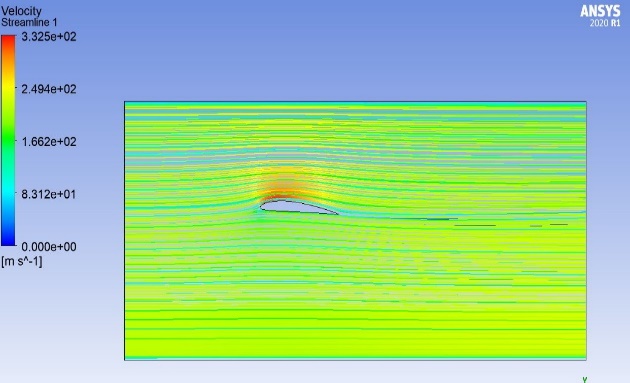
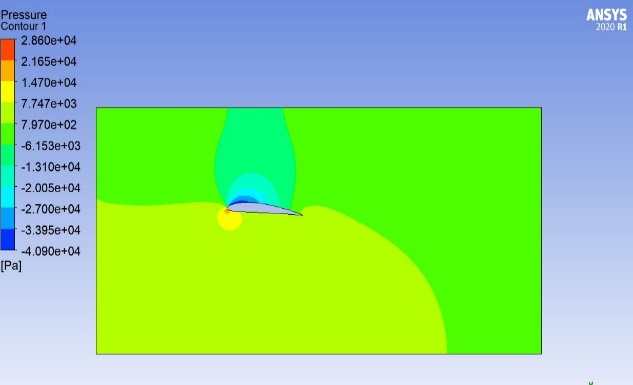


Figure 8 Pressure and Velocity Contour

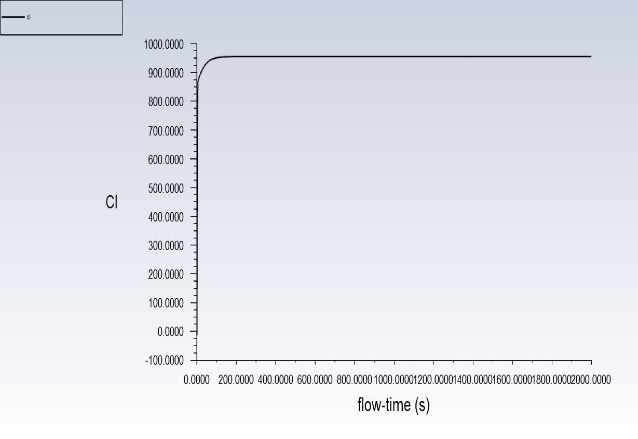
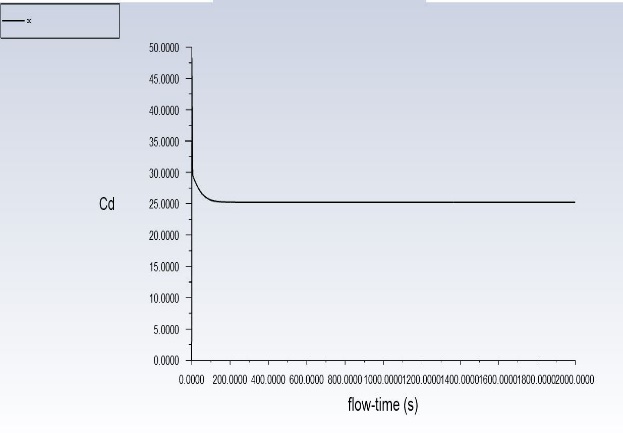


Figure 9 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 4) 6 Degree Angle of Attack.

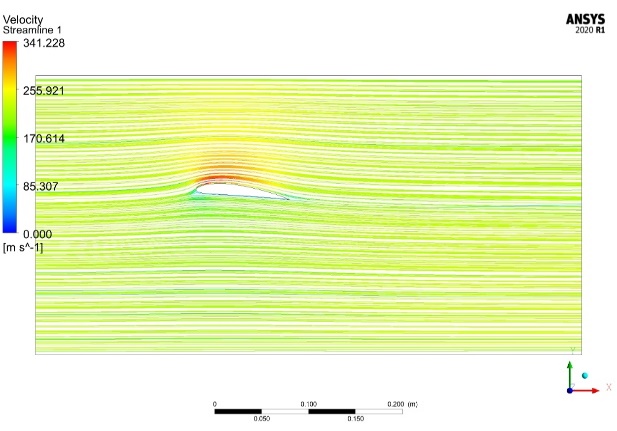
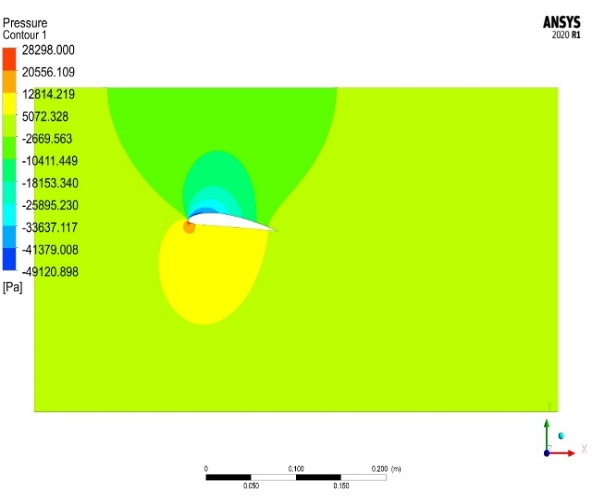


Figure 10 Pressure and Velocity Contour

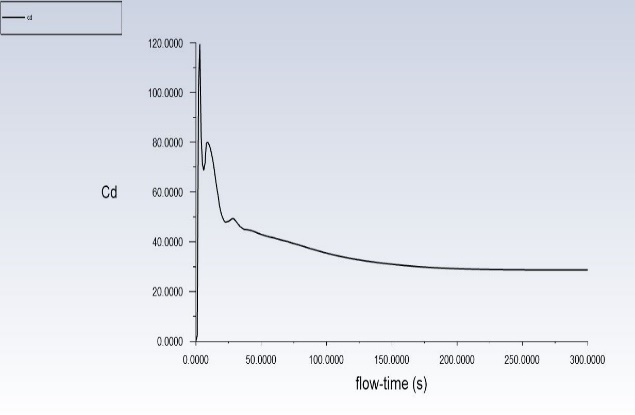
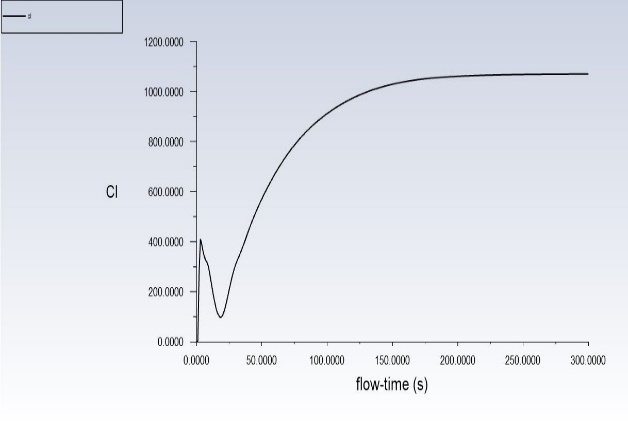


Figure 11 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 5) 9 Degree Angle of Attack

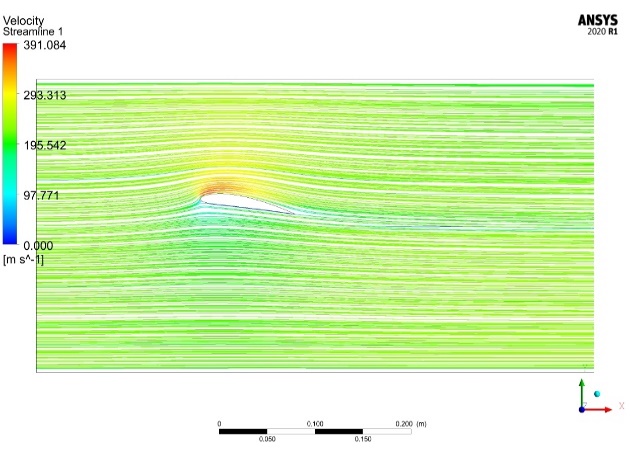
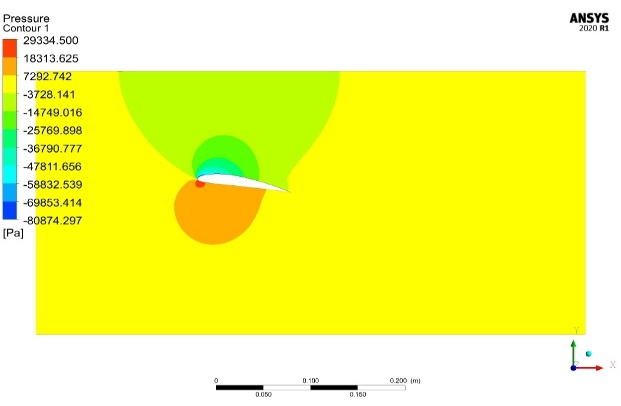


Figure 12 Pressure and Velocity Contour

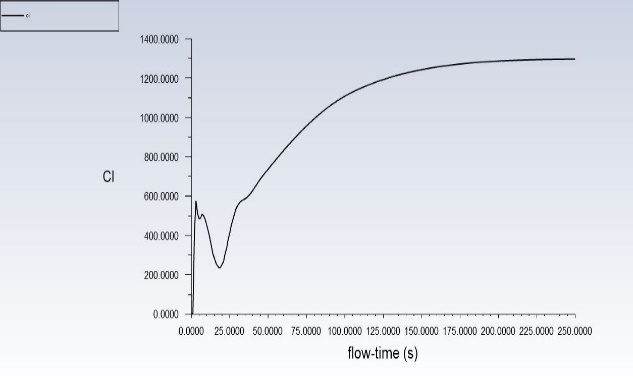
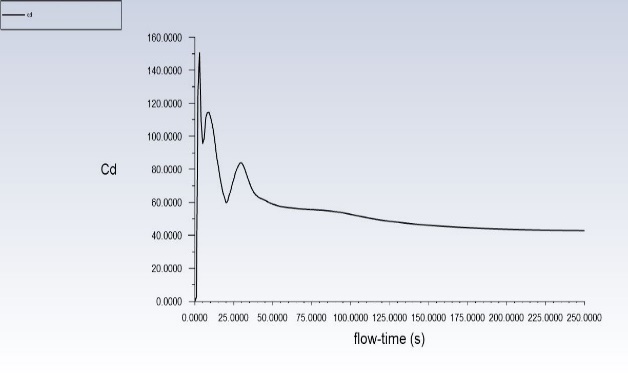


Figure 13 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 6) 12 Degree Angle of Attack

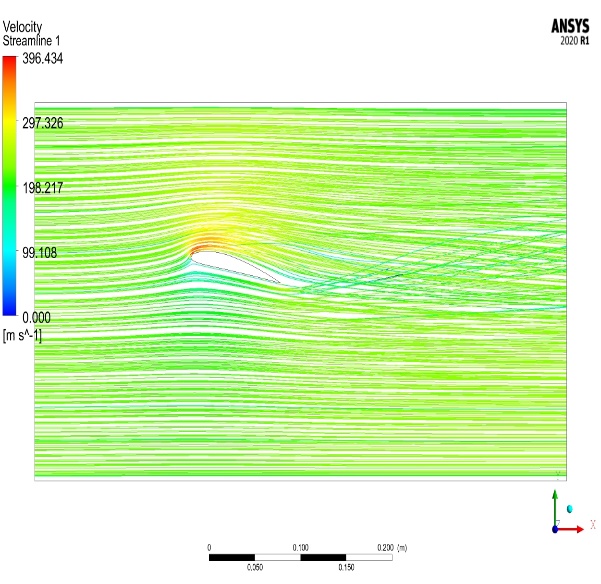
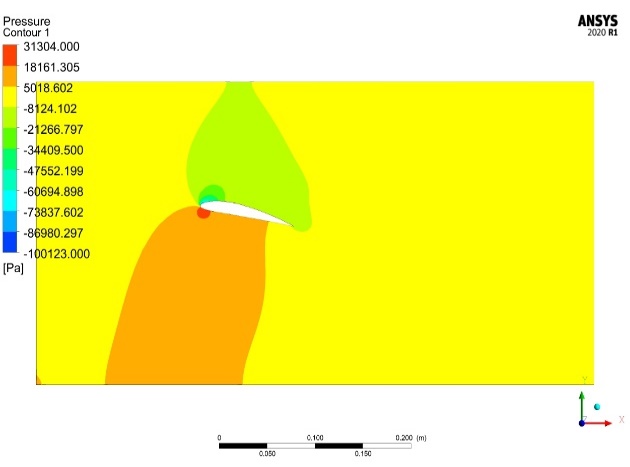


Figure 14 Pressure and Velocity Contour

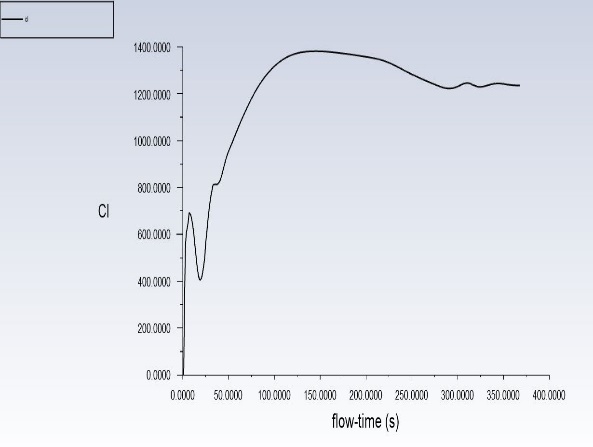
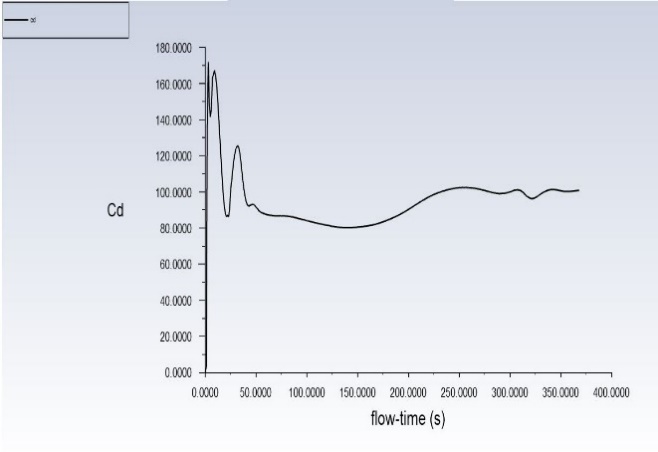


Figure 15 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 7) 15 Degree Angle of Attack

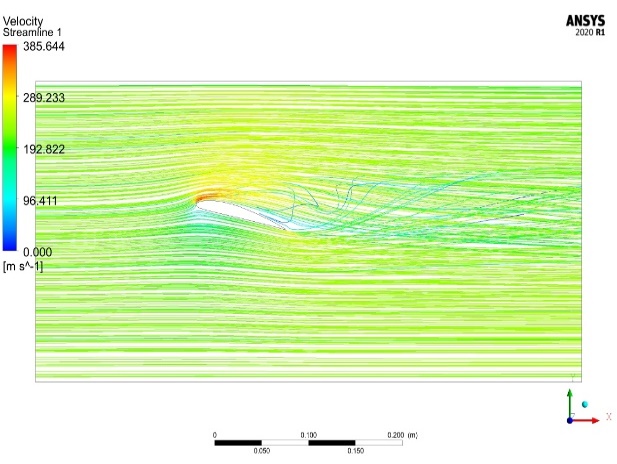
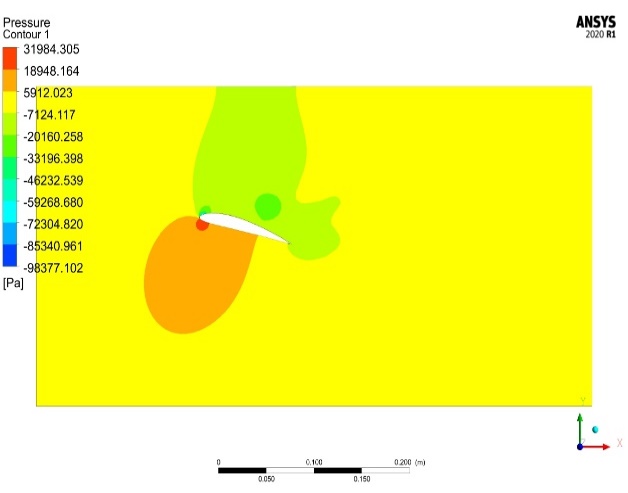


Figure 16 Pressure and Velocity Contour

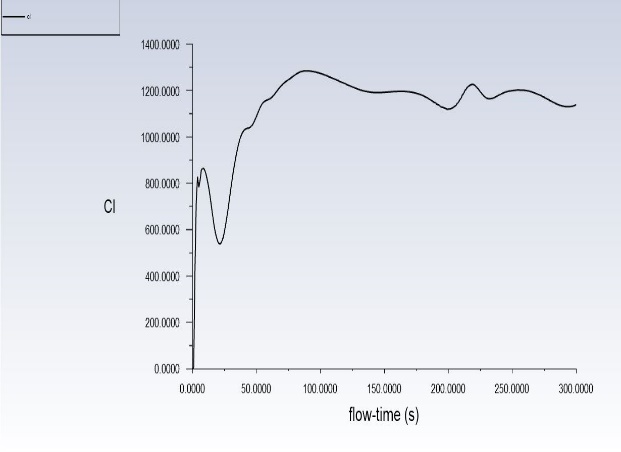
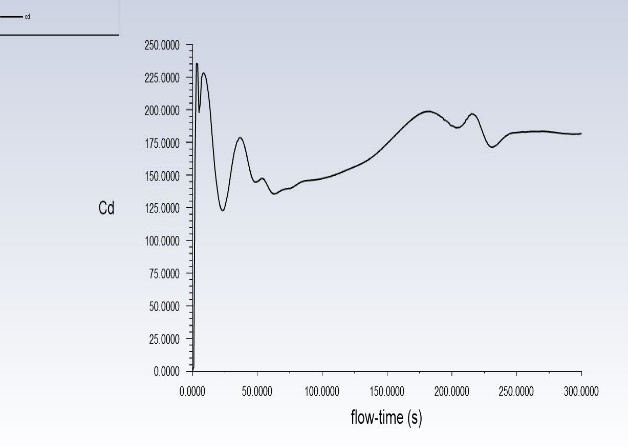


Figure 17 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 8) 18 Degree Angle of Attack

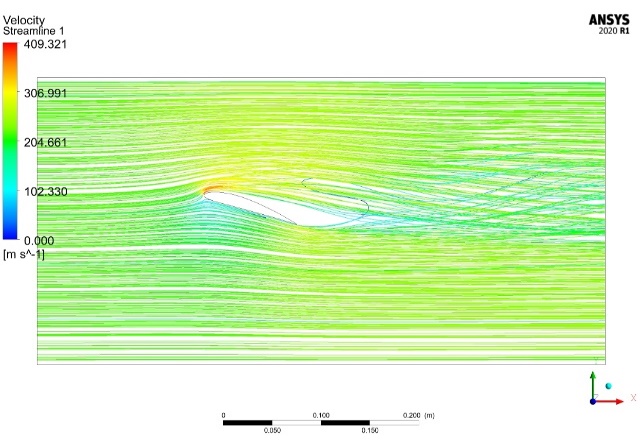
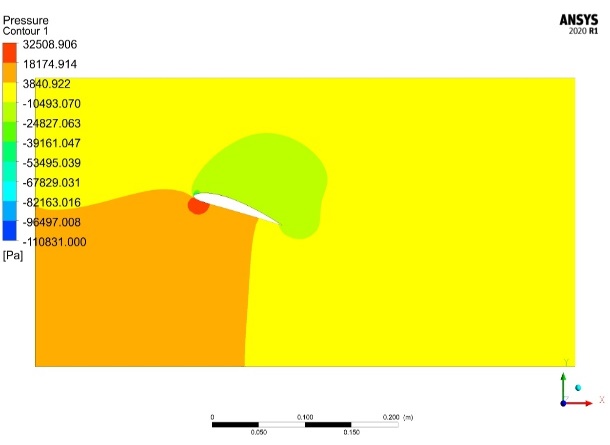


Figure 18 Pressure and Velocity Contour

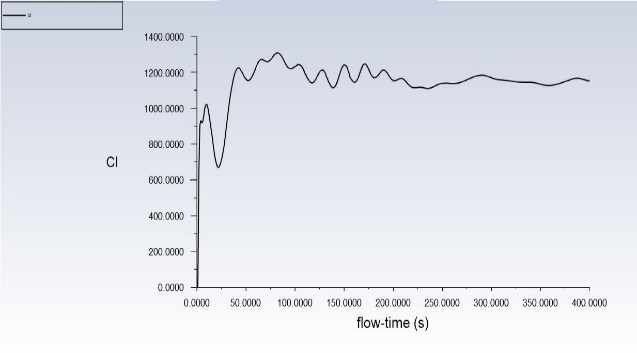


Figure 19 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 9) 21 Degree Angle of Attack

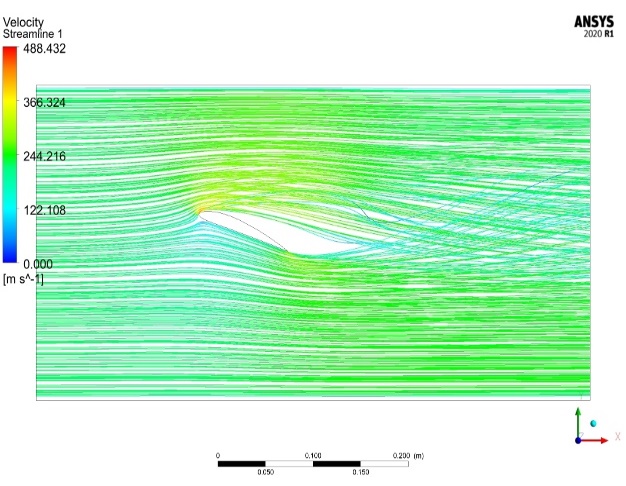
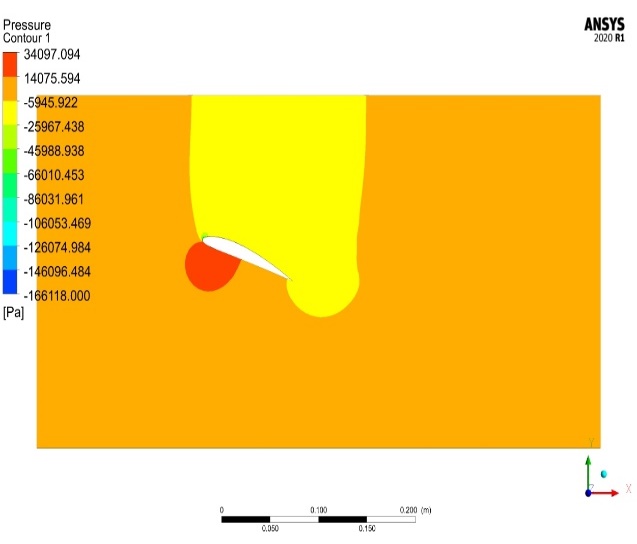


Figure 20 Pressure and Velocity Contour

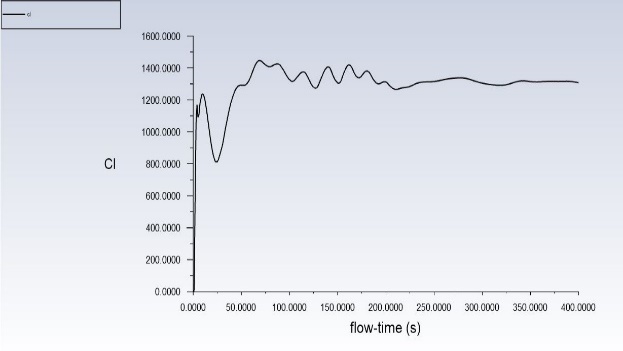
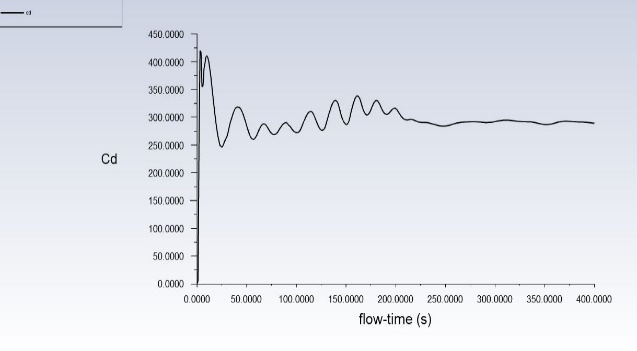


Figure 21 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 10) 24 Degree Angle of Attack

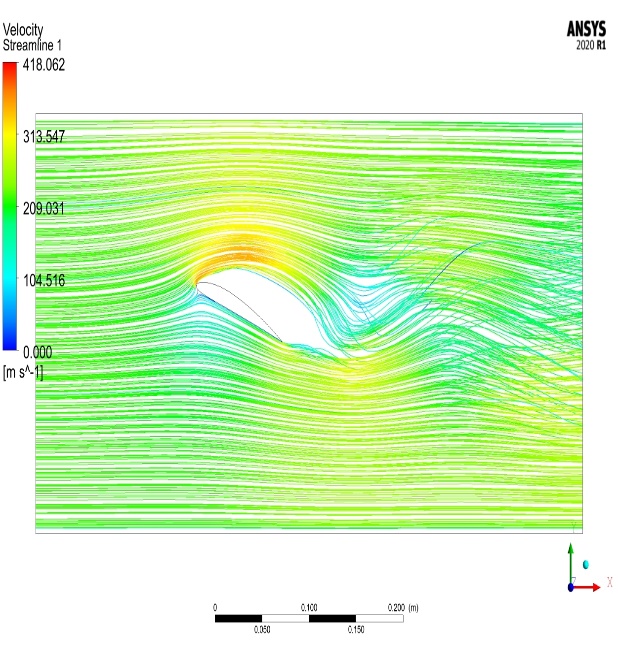
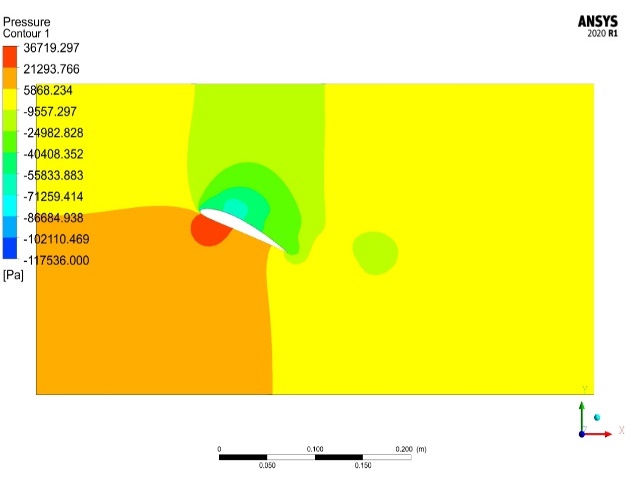


Figure 22 Pressure and Velocity Contour

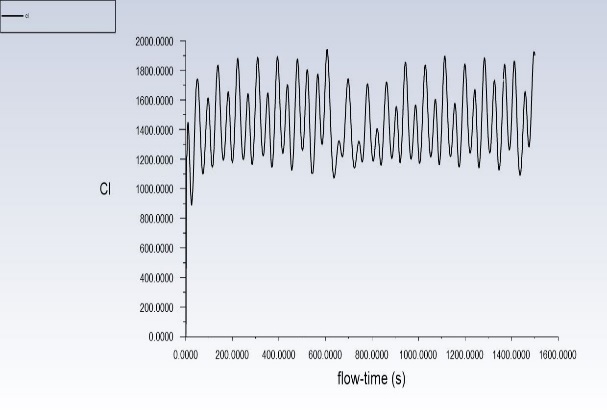
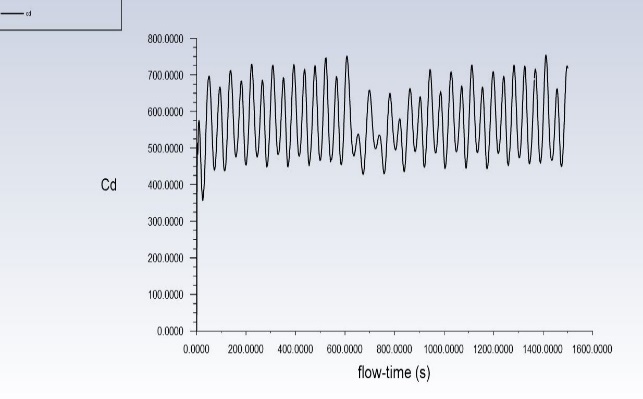


Figure 23 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 11) 27 Degree Angle of Attack

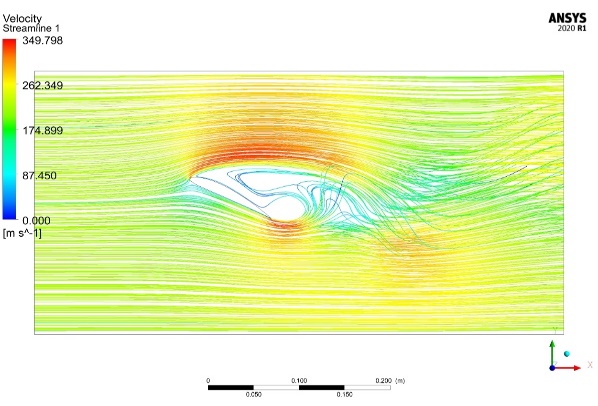
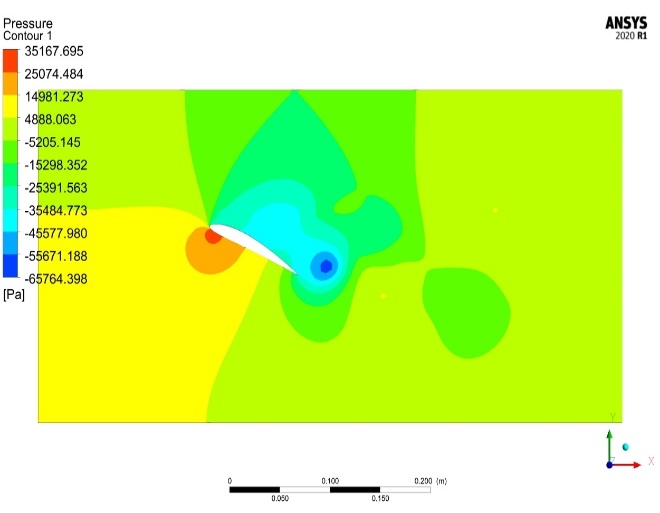


Figure 24 Pressure and Velocity Contour

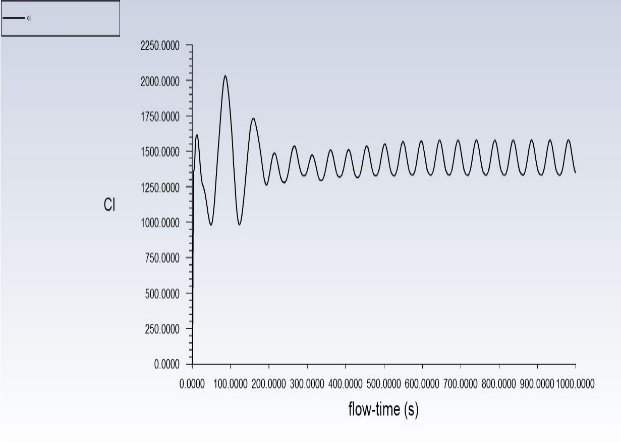
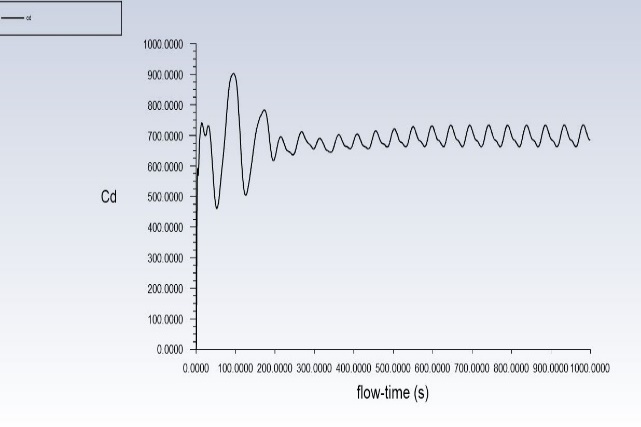


Figure 25 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

### Case 12) 30 Degree Angle of Attack

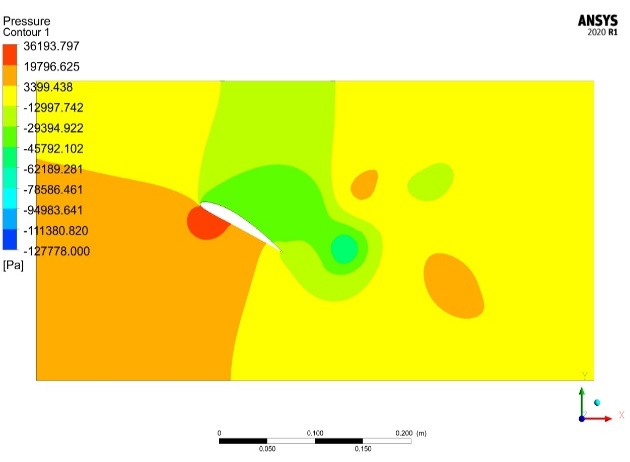


Figure 26 Pressure and Velocity Contour

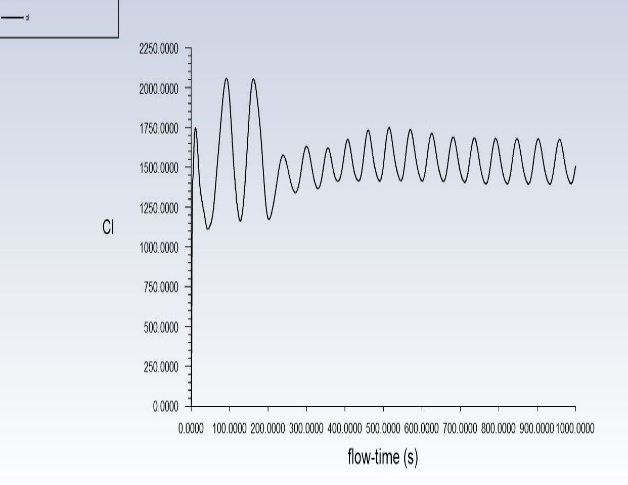
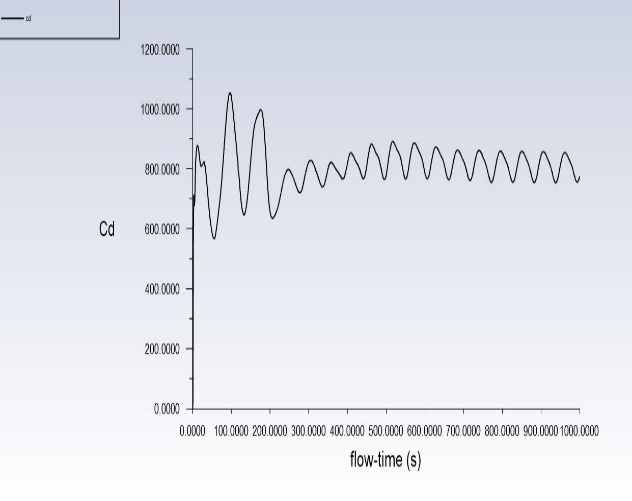


Figure 27 Convergence graph of forces a) Coefficient of Drag and b) Coefficient of Lift

## **3.2 Discussion and Validation of Study**

Graph 1. Coefficient of Lift

![Chart, line chart

Description automatically 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Graph 2. Coefficient of Drag

![Chart, line chart

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4REARXhpZgAATU0AKgAAAAgABAE7AAIAAAASAAAISodpAAQAAAABAAAIXJydAAEAAAAkAAAQ1OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE5pcmFuamFuIFNvbmF3YW5lAAAFkAMAAgAAABQAABCqkAQAAgAAABQAABC+kpEAAgAAAAM0NAAAkpIAAgAAAAM0NAAA6hwABwAACAwAAAieAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Graph 3. Vortices with increasing Angle of Attack

![Chart, line chart

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4REARXhpZgAATU0AKgAAAAgABAE7AAIAAAASAAAISodpAAQAAAABAAAIXJydAAEAAAAkAAAQ1OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE5pcmFuamFuIFNvbmF3YW5lAAAFkAMAAgAAABQAABCqkAQAAgAAABQAABC+kpEAAgAAAAM5MQAAkpIAAgAAAAM5MQAA6hwABwAACAwAAAieAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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## **3.3 Result Validation**

The results are validated using Experimental wind tunnel Data by [16] which suggests that the creation of Drag and vortices increase by the increasing angle of attack.

# **4. CONCLUSION**

The Computational CFD investigation over NACA 4412 Airfoil is carried out using commercial coded Ansys Fluent software. The creation of Coefiecnt of lift and drag by increasing angle of attack is shown in the present investigation. The correlation of vortices generation is also validated computationally in CFD. The following conclusion can be drawn

1. The creation of LIFT COEFFICIENT is tended to increase by the increasing angle of attack and the maximum lift coefficient is achieved at 24 Degree Angle of Attack which suggests a stagnation point because increasing further increment angle is the result in decreasing Coefiecnt of lift.
2. The coefficient of drag in direct proportion quantity with lift coefficient, The drag coefficient increase by increasing angle of attack, the stagnation point which is found as 24 Degree suggest the highest amount of drag creation in the grid for Airfoil.
3. The Vortices formulation over Airfoil is tended to increase by increasing Angle of Attack and as the stagnation point is achieved at 24 Degree Angle of Attack the Stall is created and Vortices magnitude in shedding cycle also increases. The Time scale factor with 0.005 Second per cycle is kept to accurately monitor vortices creation

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