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A Good Effect of Airfoil Design While Keeping Angle of Attack by 6 Degree

[1]Dr.V.N. Bartaria, [2]Shivani Sharma

[1]HOD MECHANICAL LNCT BHOPAL
[2]BE MECHANICAL, PURSUING M.TECH

Abstract: **Airfoil is a shape of wing or blade of (a propeller, rotor or turbine) by which a fluid generates an aerodynamic force. The component of this force perpendicular to the direction of its speed is called lift force and the component parallel to its speed is called drag forces. Here we see that if we set the angle of attack by 6 degree in fluid NACA0012 we found the aerodynamic forces with suitable positive result our research is totally based on iterations method and based on the help of cfd software.**

Keywords: **Airfoil, angle of attack, lifts force, drag force.**

1. INTRODUCTION

It is a fact of common life that a body in some speed through a fluid experience a resultant force which, in most cases is mainly a obstacle to the speed. A class of body exists, However for which the component of the resultant force normal to the direction to the motion is many time greater than the body resist the speed, and the flight of an air plane depends on the use of the body of this class for wing structure. Airfoil is such an aerodynamic shape that when it moves through air, the air is split and passes above and below the wing. The wing's upper surface is shaped so the air rushing over the top speeds up and stretches out. This decreases the air pressure above the wing. The air flowing below the wing moves in a comparatively straighter line, so its speed and air pressure remains the same. Since high air pressure always moves toward low air pressure, the air below the wing pushes upward toward the air above the wing. The wing is in the middle, and the whole wing is "lifted." The faster an airplane moves, the more lift there is. And when the force of lift is greater than the force of gravity, the airplane is able to fly.

2. AIRFOILS NOMENCLATURE

An airfoil is a body of such a shape that when it is placed in an airstreams, it produces an aerodynamic force. This force is used for different purposes such as the cross sections of wings, propeller blades, windmill blades, compressor and turbine blades in a jet engine, and hydrofoils are examples of airfoils. The basic geometry of an airfoil is shown in Figure 1.

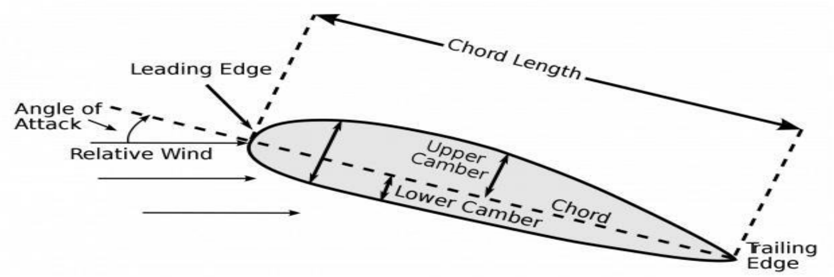

Figure 1: Basic nomenclature of an airfoil

The leading edge is the point at the front of the airfoil that has maximum curvature. The trailing edge is defined similarly as the point of maximum curvature at the rear of the airfoil. The chord line is a straight line connecting the leading and trailing edges of the airfoil. The chord length or simply chord is the length of the chord line and is the characteristic dimension of the airfoil section. The leading edge is the point at the front of the airfoil that has maximum curvature. The trailing edge is defined similarly as the point of maximum curvature at the rear of the airfoil. The chord line is a straight line connecting the leading and trailing edges of the airfoil. The chord length or simply chord is the length of the chord line and is the characteristic dimension of the airfoil section.

3. ANGLE OF ATTACK (AOA)

AOA is the angle between the oncoming air or relative wind and a reference line on the airplane. Sometimes the reference line is a line connecting the leading edge and trailing edge at some average point on a wing. Most commercial jet airplanes use the fuselage centre line or longitudinal axis as the reference line. It makes no difference what the difference line is as long as it used as consistently. As the nose of the wing turns up, AOA increases, and lift increases. Drag goes up also, but not as quickly as lift. During take-off an airplane builds up to a certain speed and then the pilot "rotates" the plane that is, the pilot manipulates the controls so that the nose of the plane comes up and, at some AOA, and the wings generate enough lift to take the plane into the air. Since an airplane wing is fixed to the fuselage, the whole plane has to rotate to increase the wing's angle of attack. Front wings on race cars are fabricated so the angle of attack is easily adjustable to vary the amount of down force needed to balance the car for the driver.

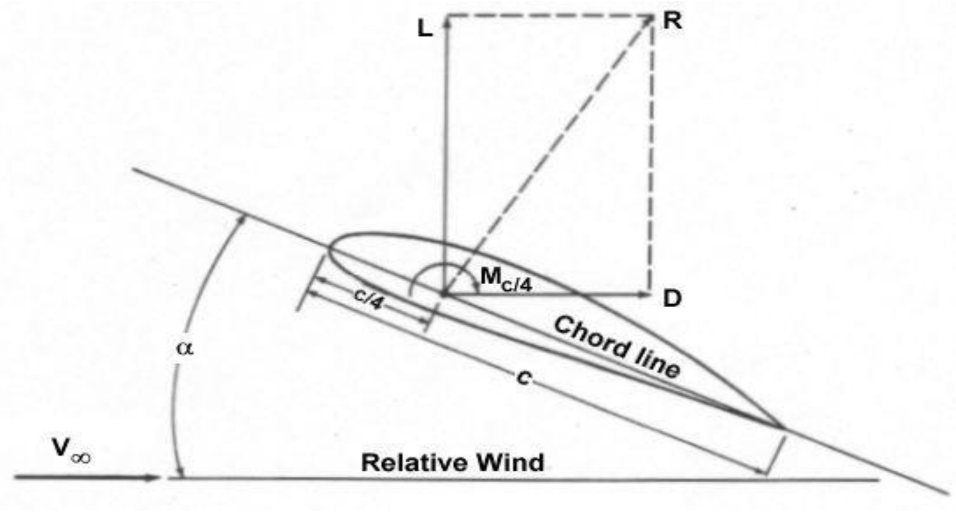

Figure 2: Angle Of Attack

4. COEFFICIENT OF DRAG AND COEFFICIENT OF LIFT

The drag equation,

Fd = $\frac{1}{2}$ rn^2 CdA

So co efficient of drag is given by the,

CD= 2Fd / rn^2A

Is needed a statement that the drag force on any object is proportional to the mass upon volume of the fluid and proportional to the square of the relative speed between the object and the fluid. In fluid dynamics the *Cd* is a dimensionless amount that is used to amounting the resistance of purpose in a fluid condition as air or water. It is used in the drag formula where a less CD indicates the object will have lower aerodynamic. The CD always associated with a particular surface area. The drag coefficient of any object comprises the effects of the two basic contributors to fluid dynamic drag .The CD of a lifting airfoil or hydro foil also includes the effects of lift induced drag. The CD of a whole structure as an air craft also includes the effects of interference drag. The overall CD defined in the usual is The reference area depends on what type of drag coefficient is being measured . This may not necessarily be the cross sectional area of the vehicle, depending on where the cross section is taken and for an airfoil the surface area is a plane form area. The lift formula,

$$L = \frac{1}{2} rn^2 \ A\ CL$$

So coefficient of lift is given by the,

CL = 2L/rn^2S =L/qs

When a fluid is flow over a body its exert a force on it. lift is the component which is perpendicular to the fluid flow and drag is the component which is parallel to the fluid flow. It is called aerodynamic force when fluid is air.

5. RELATIONSHIP BETWEEN AOA, CD AND CL

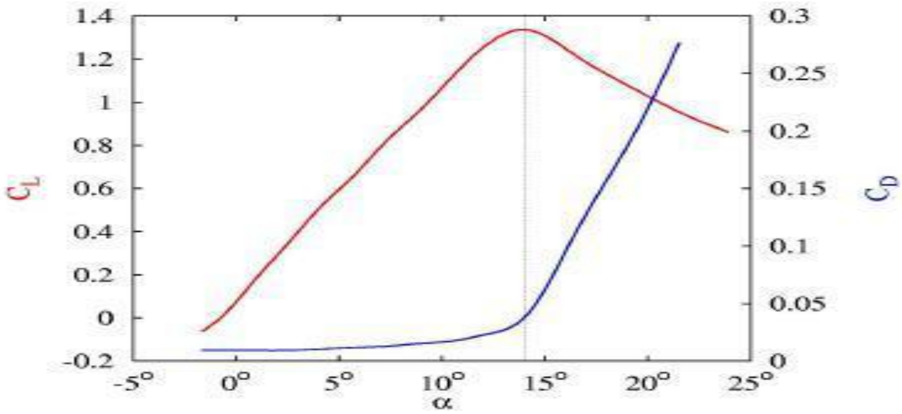

Figure 3: Relationship of Different Coefficients

The CL of fixed-wing changes with AOA. On increasing AOA is associated with increasing CL up to the maximum CL, after which CL decreases. As the AOA of fixed-wing aircraft increases, separation of the airflow from the above surface of the wing becomes more pronounced, leading to a reduction in the rate of increase of the lift coefficient. The figure shows a typical curve for a cambered straight wing. A uniform wing has 0 lift at zero degrees angle of attack. The lift curve is also influenced by wing platform. A swept wing has a lower, flatter curve with a higher critical angle. Identically the value of drag coefficient is 0 at the 0 angle of attack and it increase slowly till the stall condition and at the time of stall as well as after stall it increase readily as shown in figure 3. Particular air speed, the air speed at which the air craft stalls varies with the weight of the air craft the load factor the centre of gravity of the air craft and other factors. However the air craft always stalls at the same critical AOA. The critical or stalling AOA is typically around fifteen degree for many airfoils.

6. BASICS INPUTS

Table 1: ambient conditions

NO	INPUTS	VALUE
1	Velocity of flow	51 m/s
2	Applied temperature	300 k
3	Applied pressure	101.325 kPa
4	Model	Transition sst (4th equation)
5	Density of fluid	1.225 Kg/m3
6	Kinematic viscosity	1.4607 × E-5
7	Reynolds number	3.5 × E+6
8	Length	1 Meter
9	AOA	0 degree and 6 degree respectively
10	Fluid	Air as a ideal

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CFD analysis steps:

Table 2:- common steps to performing the cfd analysis

No	**Steps**	**Process**
1	Problem statement introduction	Details Regarding the flow
2	Making Mathematical model	Generate 3D model
3	Mesh generation	Nodes/cells,
4	Space discretization	Coupled ODE/DAE systems
5	Time discretization	Algebraic system Ax=b
6	Iterative solver	Discrete function values
7	CFD software	Implementation, debugging
8	Simulation run	Parameters, stopping criteria
9	Post processing	Visualization, analysis of data
10	Verification	Model validation / adjustment
11	Saving case and data	Save all the obtain data
12	Comparing	Comparing the outcome values with real practical values

Mesh Generation on airfoil NACA0012:

To get order of fluid flow and to analyze its flow domains and sub domains to governing the equations for solving meshed area around the airfoil is shown in below.

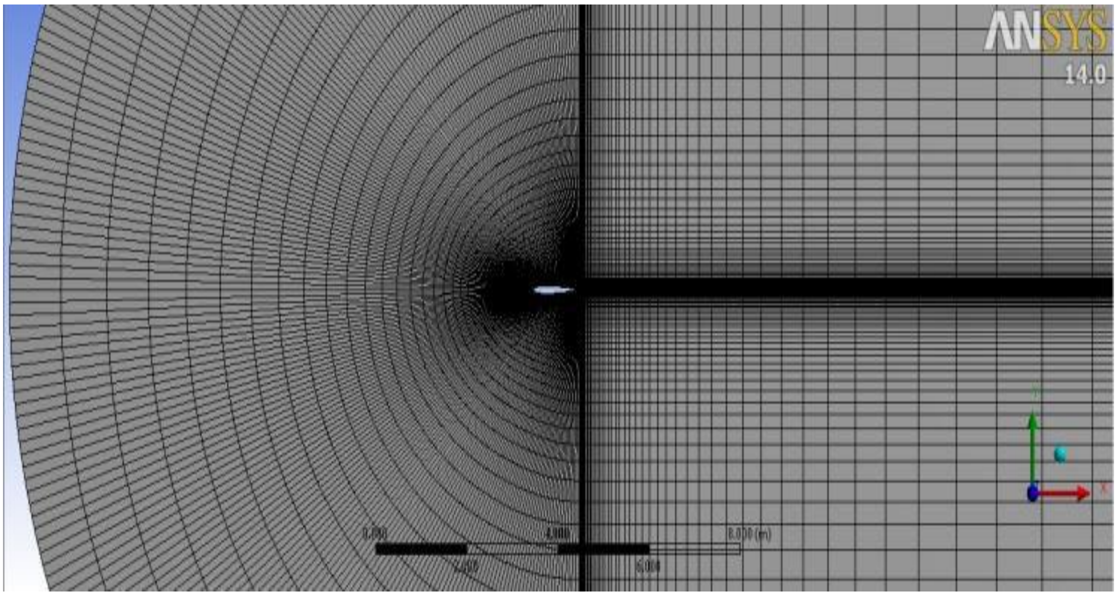

Figure 4 : Mesh Generation and its Region

Contours of Static Pressure:

The static pressure of the air is simply the weight per unit area of the air above the level under consideration. For instance, the weight of the column of air with a cross-sectional area of 1 ft-2 and extending upward from sea level through the atmosphere is 2116 lb. The sea level static level is therefore 2116 psf. Static pressure is decrease as altitude is increased because there is less air weight above. At 18,000 ft altitude the static pressure is about half that at sea level. The amalgamation of static pressure and dynamic pressure is known as total pressure.

For AOA is 0 deg we get that contours of static pressure over an aerofoil is uniform for upper and bottom surface and the stagnation point is same at the front of an airfoil.thats why there is 0 pressure different formed between 2 faces of airfoil at 0 degree of an AOA.

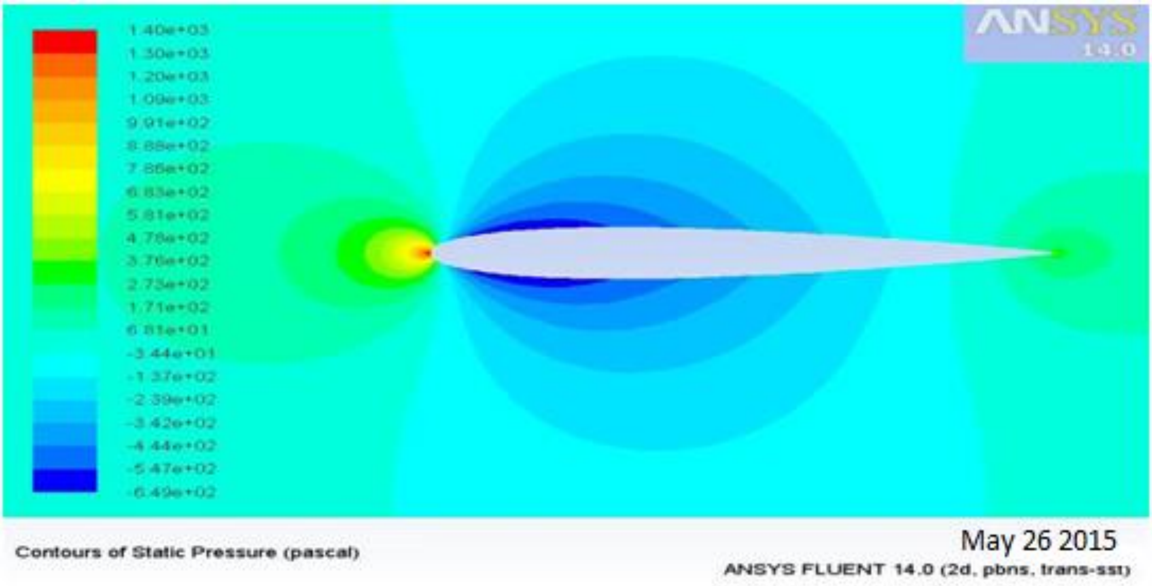

Figure 5:- Contours of static pressure at zero degree of AOA

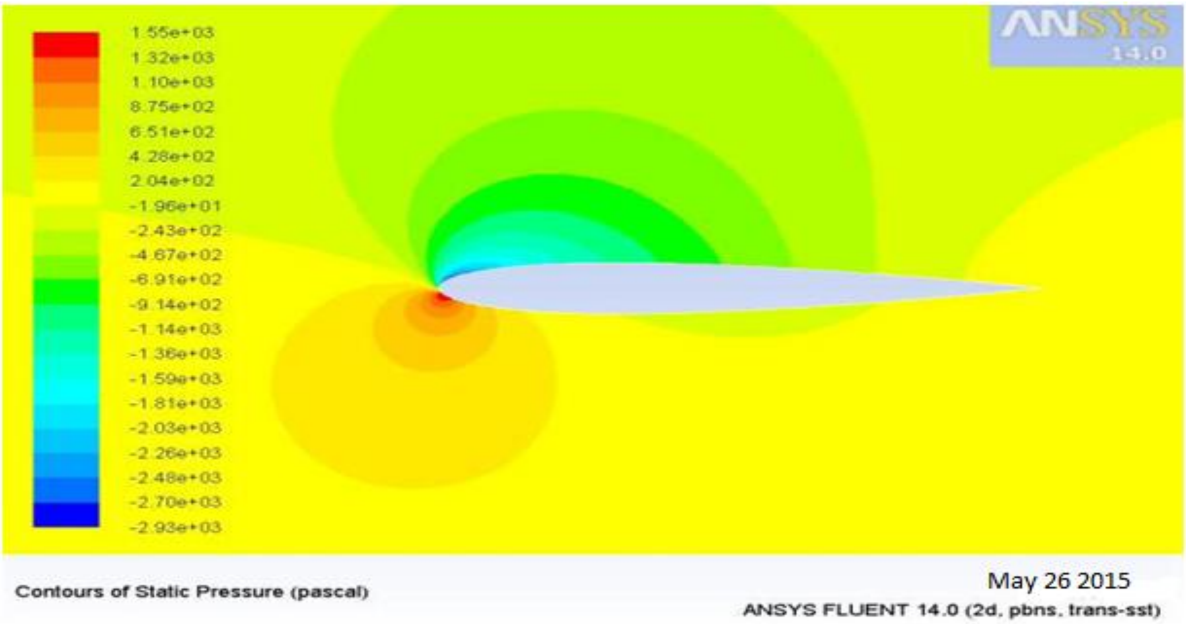

Figure 6:- Contours of static pressure over at six degree of Angle Of Attack

For an AOA of six degrees, we can see flow has been a stagnation point just under the leading edge and thats why producing lift as there is a low pressure area on the upper surface of the airfoil as shown in Figure 6. We also note that Bernoulli's theory is comes correct ; the velocity is more (shown by red contours) at the less pressure region and same as in reverse . There is a area of more pressure on leading edge (stagnation point) and region of less pressure on the upper surface of airfoil.

Velocity contours:

In figure 7-8 at the zero deg of Angle Of Attack velocity contours are same as symmetrical and at six degree of Aangle Of Attack the stagnation point is in small goes to the trailing edge from bottom surface that's why it will create less velocity area at lower side of the airfoil and more velocity acceleration area at the upper side of the airfoil and by to theory of Bernoulli's upper surface will gain less pressure and lower surface will gain more pressure. Hence amount of CL will increase and Cd will also increase but the increasing in drag is low as compare to increasing in lift force.In a uniform

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airfoil at no incidence, the variation of velocity and the pressures along both surfaces area would have been same the same, according each other to a resulting lift force of 0.

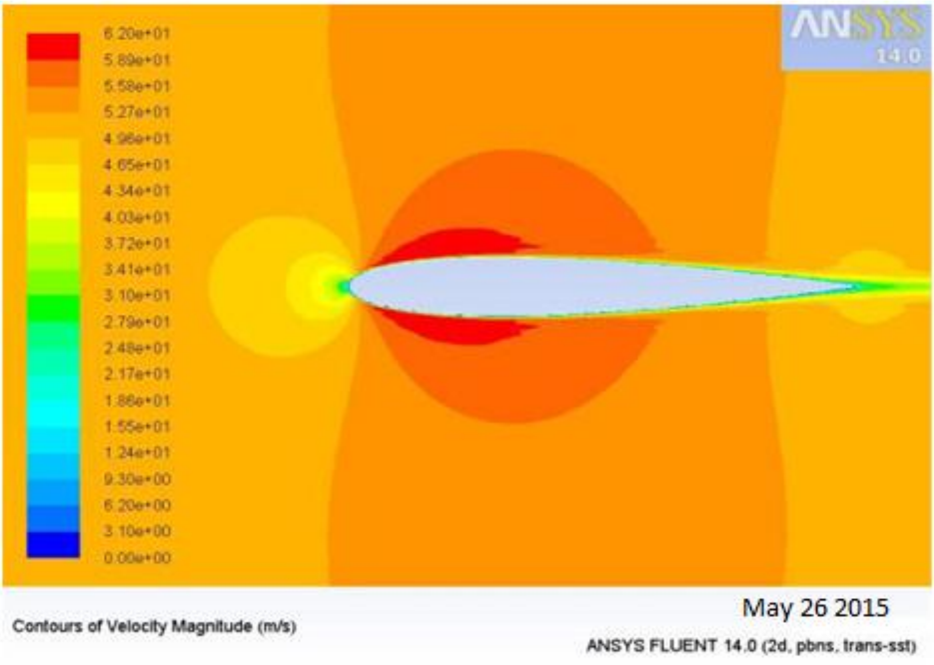

Figure 7: At zero degree angle of attack

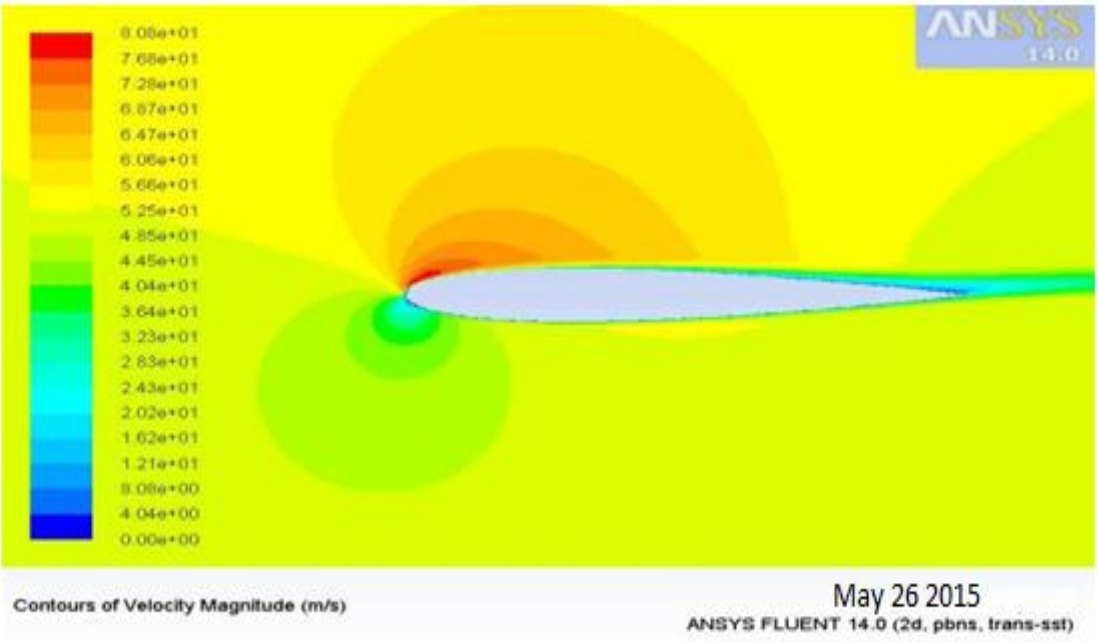

Figure 8: At 6 degree of angle of attack contours of velocity

5. CONCLUSION

By the help of CFD analysis we were get that on the flow over fluid NACA0012 air foil cross section we came to the conclusion on ZERO degree angle of attack is not produce any lift force for getting increase on lift force and also increase in lift coefficient we have to increase on the value of angle of attack .After its perform its naturally value of drag force and amount of drag coefficient increased but its lower then lift force and its coefficient .Its numerical value is as below.

Experimental resultant value and its graph:

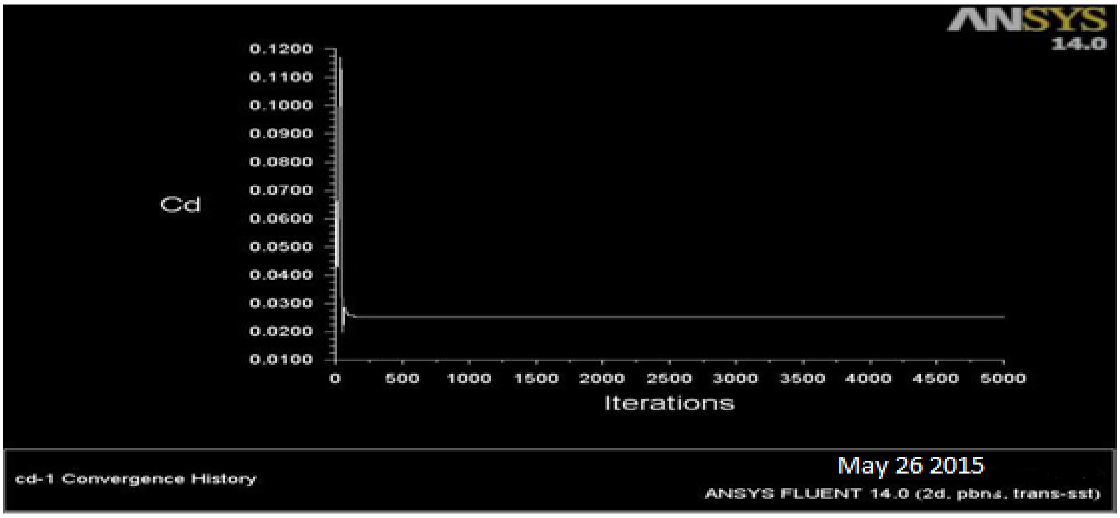

Figure 9: At six degree of angle of attack .

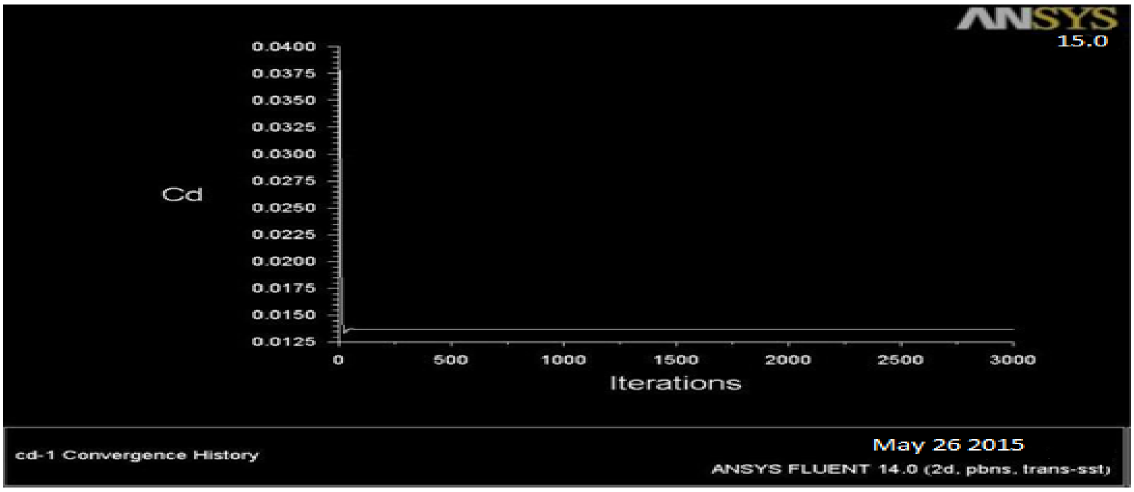

Figure 10: At zero degree of angle of attack.

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