CFD ANALYSIS ON NACA S6061 AT VARIOUS ANGLE OF ATTACK

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Abstract

The main aim is to analyze the NACA S6061 aerofoil with or without gurney flap at various angles of attack[1][4][5][6]. 2D analysis was performed to determine the effect of a gurney flap on aerofoil at a constant low Reynolds number[2][3]. The gurney flap was attached at the trailing edge of the aerofoil and was perpendicular to the chord lounge of the aerofoil. The height of gurney flap varies from 1 to 5% of the chord length and at an angle of attack which varies from 0, 2, 4, 6 and 8 degrees. The analysis and calculation is done by using ANSYS FLUENT simulation approach which shows that addition of a gurney flap increases the lift coefficient and there is a slight increase in the drag coefficient.

Keywords: Reynolds number; CFD; Aerofoil; 2D analysis; NACA S6061; Gurney flap.

I. Introduction

As a part of study, a 2 dimensional computational fluid dynamics analysis has been carried on ANSYS FLUENT. Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical analysis and data structures to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. ANSYS FLUENT software contains the broad physical modeling capabilities needed to model flow, turbulence, heat transfer, and reactions for industrial applications ranging from air flow over an aircraft wing to combustion in a furnace. Special models that give the software the ability to model in-cylinder combustion, aero acoustics, turbo machinery, and multiphase systems have served to broaden its reach. Gurney Flap is named after its inventor and developer Dan Gurney. It is a small tab projecting from the trailing edge of a wing. Typically it is set perpendicular to the pressure side surface of the airfoil and projects 1% to 2% of the wing chord. This trailing edge device can improve the performance of a simple airfoil to nearly the same level as a complex high-performance design. The device operates by increasing pressure on the pressure side, decreasing pressure on the suction side, and helping the boundary layer flow stay attached all the way to the trailing edge on the suction side of the airfoil. The Gurney flap increases the maximum lift coefficient ($C_{L,max}$), decreases the angle of attack for zero lift (α_0) which is consistent with an increase in camber of the airfoil. It also typically increases the drag coefficient (C_D). A net benefit in overall lift to drag ratio is possible if the flap is sized appropriately. The flap increases the pressure on the lower surface ahead of the flap means the upper surface suction can be reduced while producing the same lift. In this project the length of gurney flap is varies from 1% to 5% of chord length with 1% of increment. For the analysis purpose the aerofoil selected is NACA S6061 having maximum thickness of 9 % of chord length, this is low Reynolds number aerofoil. In this paper results are calculated from 0 to 8 degree of angle of attack. And results are compared for various height of gurney flap. Overall aerodynamics performance of an aerofoil can be improved by using a gurney flap. An efficient high lift system offers many advantages like lower take-off and landing speed, greater payload capacity for given wing, longer range for given gross weight and higher manoeuvrability.

II. GEOMETRY MODELLING AND MESH GENERATION

A 2-dimensional model of NACA S6061 is generated; the profile of aerofoil is in .dat file format which is completed by joining the points. NACA stands for Advisory Committee for Aeronautics, which describes the shape of aerofoil using a series of digits following the word NACA. Here S6061 is a low Reynolds number aerofoil having max thickness 9% at 34% chord, max camber 1.5% at 43.6% of chord length. In this paper comparison is made between clean aerofoil and with gurney flap aerofoil. Gurney flap length 1% to 5% is chosen. This particular gurney flap sizes are considered in order to make computational results. The flap is attached at the trailing edge with the thickness equal to the 2% of chord length. For all length of gurney flap, the thickness is kept constant. This project is mainly concern with the effect of coefficient of lift and drag. Lift is the component of this force that is perpendicular to the oncoming flow direction. It contrasts with the drag force, which is the component of the force parallel to the flow direction. Lift conventionally acts in an upward direction in order to counter the force of gravity, but it can act in any direction at right angles to the flow.

If the surrounding fluid is air, the force is called an aerodynamic force.

These forces are expressed no dimensionally by defining the coefficients of drag and lift:

$$C_D = \frac{F_D}{\frac{1}{2}\rho A U^2}$$

$$C_L = \frac{F_L}{\frac{1}{2}\rho A U^2}$$

Where F_D and F_L = drag and lift force

ρ = density

C_L= lift coefficient

C_D = drag coefficient

A = reference area

U = velocity of the undistributed flow

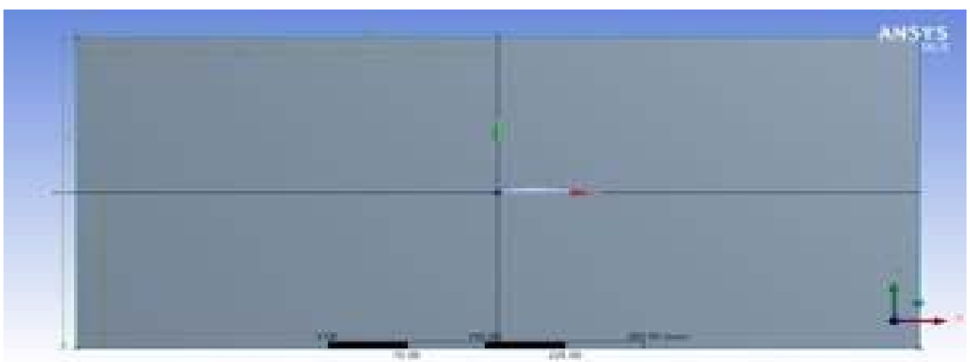

Figure1: 2D Geometry of aerofoil without gurney flap at 0^0 angle of attack

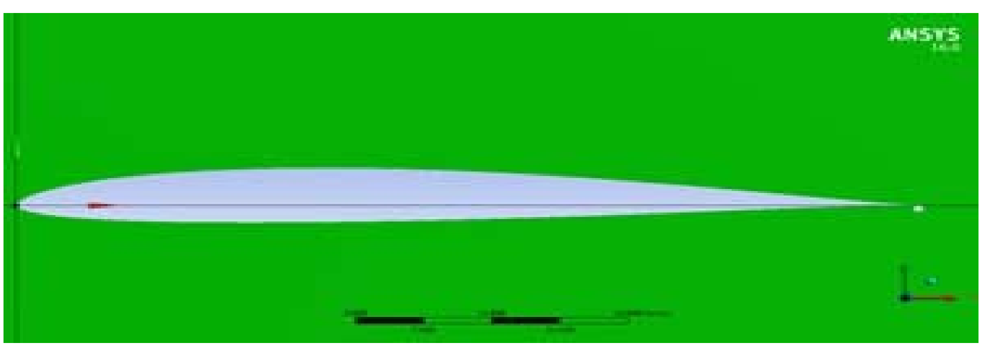

Figure 2: Aerofoil with gurney flap having height of 1% subtracted from the control volume

III RESULTS

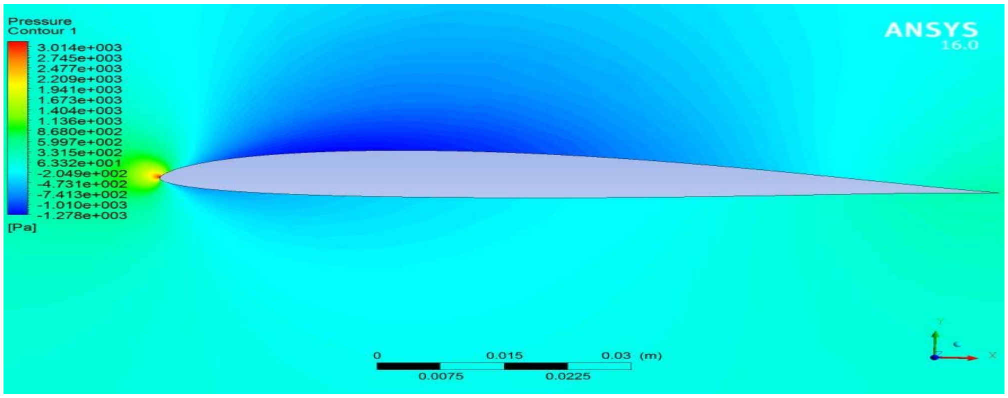

Figure 3: Pressure contours at 0 degree of angle of attack without gurney flap

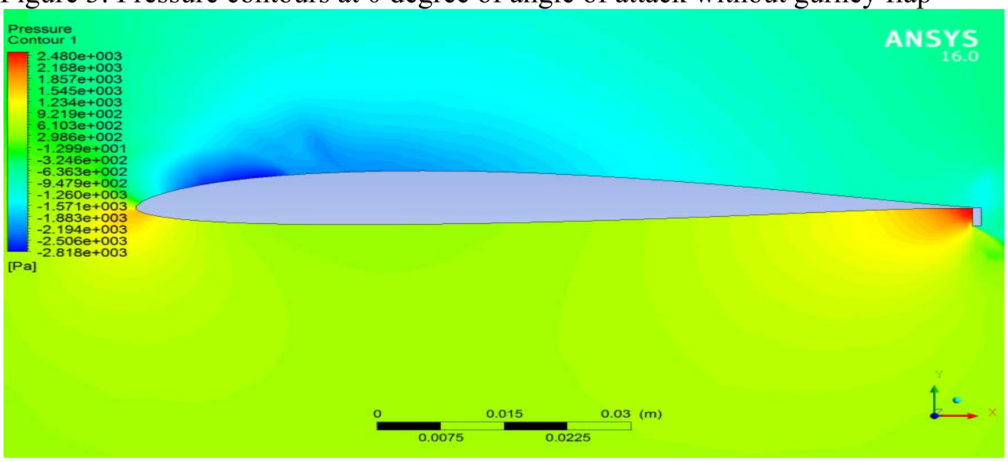

Figure 4: Pressure contours at 0 degree of angle of attack with 3% of gurney flap

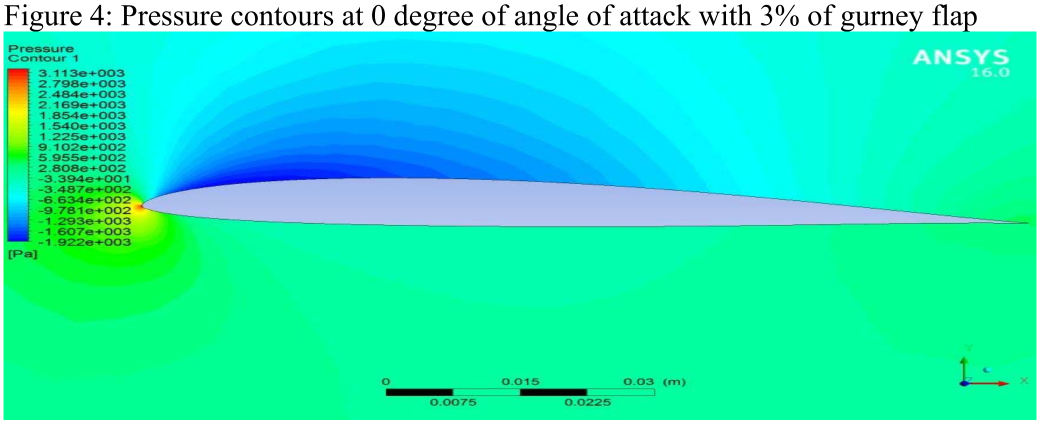

Figure 5: Pressure contours at 2 degree of angle Of attack without gurney flap

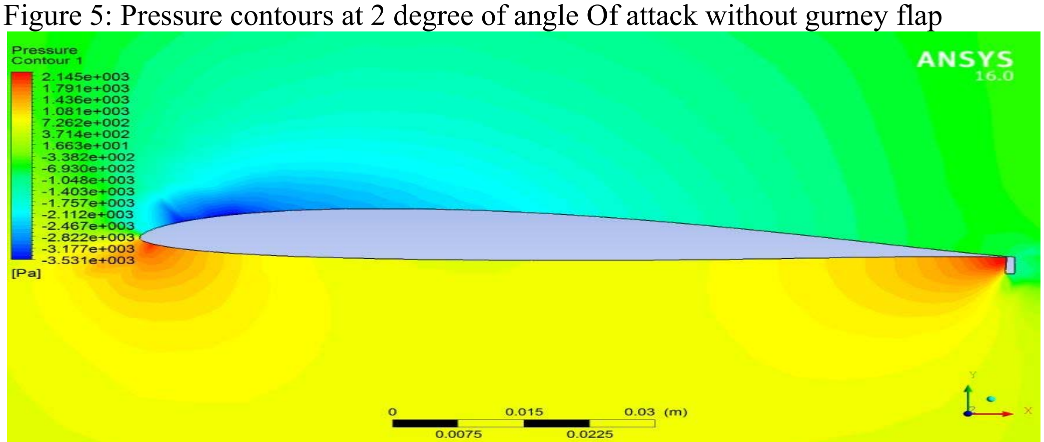

Figure 6: Pressure contours at 2 degree of angle of attack with 3% of gurney flap

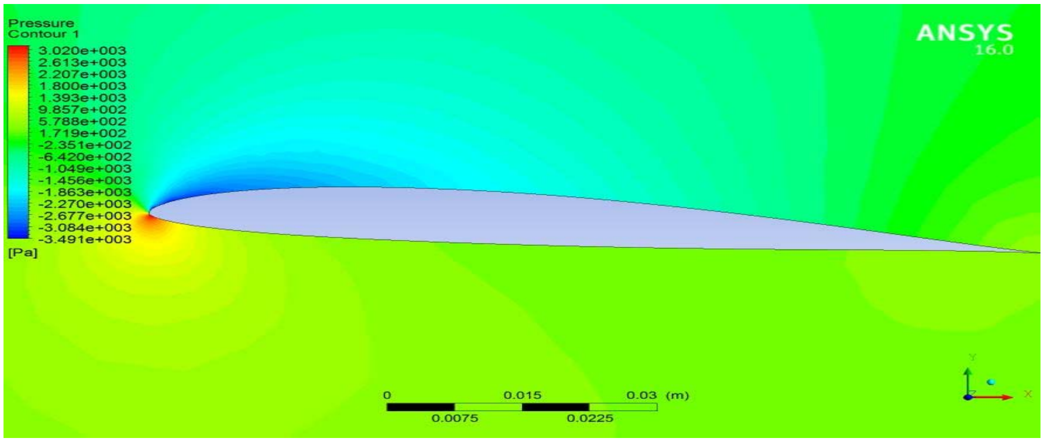

Figure 7:Pressure contours at 4 degree of angle Of attack without gurney flap

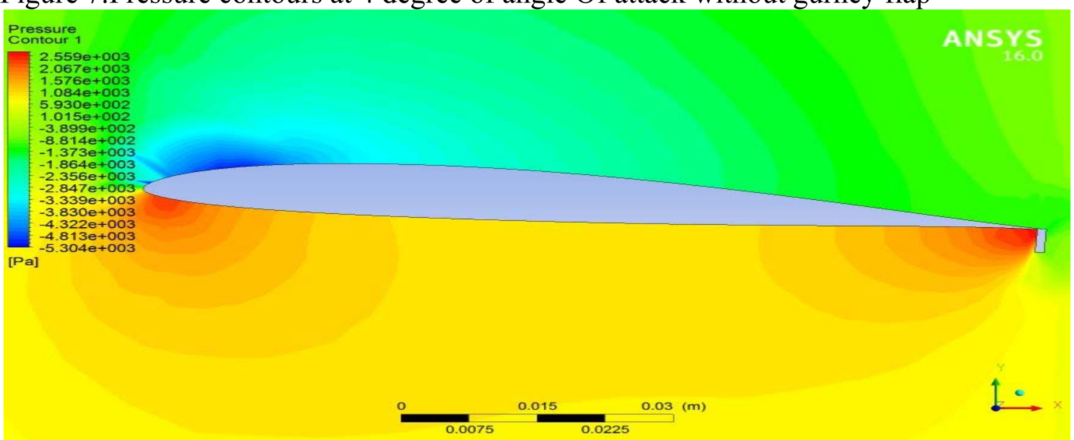

Figure 8: Pressure contours at 4 degree of angle Of attack with 4% of gurney flap

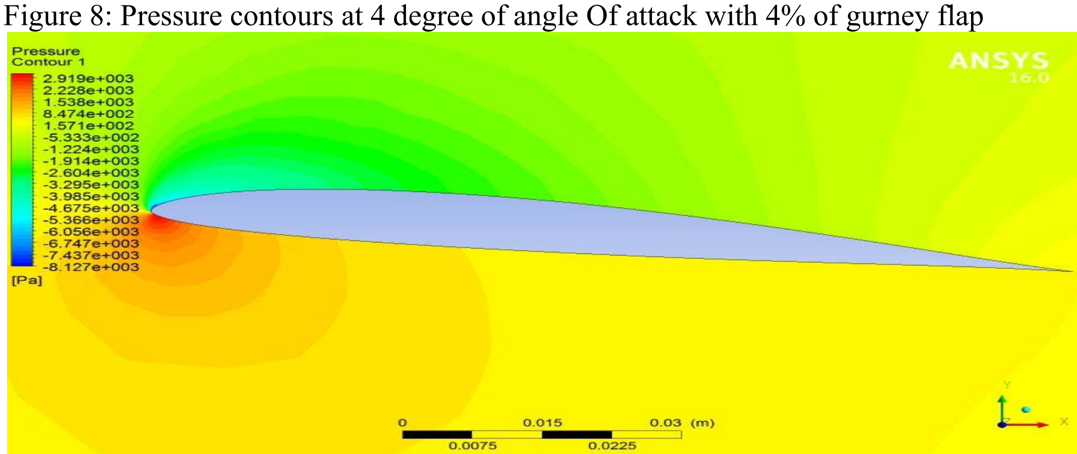

Figure 9: Pressure contours at 6 degree of angle Of attack without gurney flap

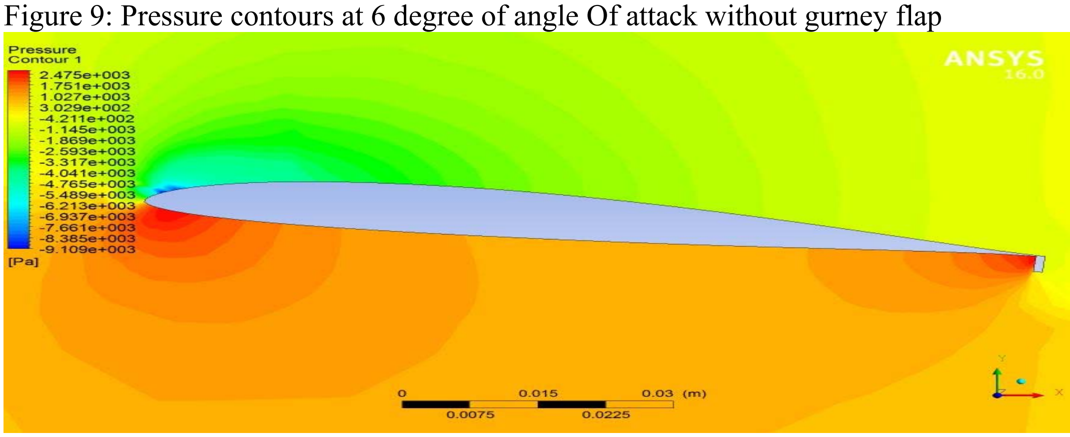

Figure 10: Pressure contours at 6 degree of angle of attack with 3% of gurney flap

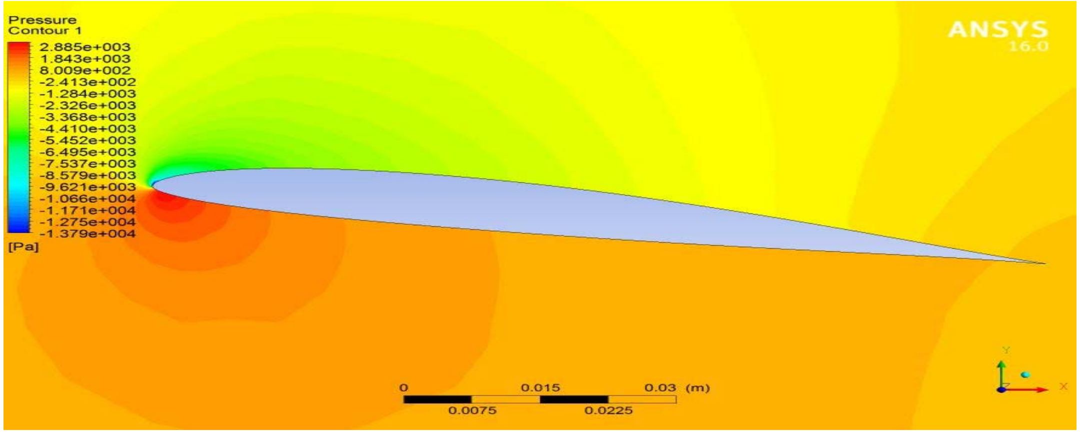

Figure 11: Pressure contours at 8 degree of angle of attack without gurney flap

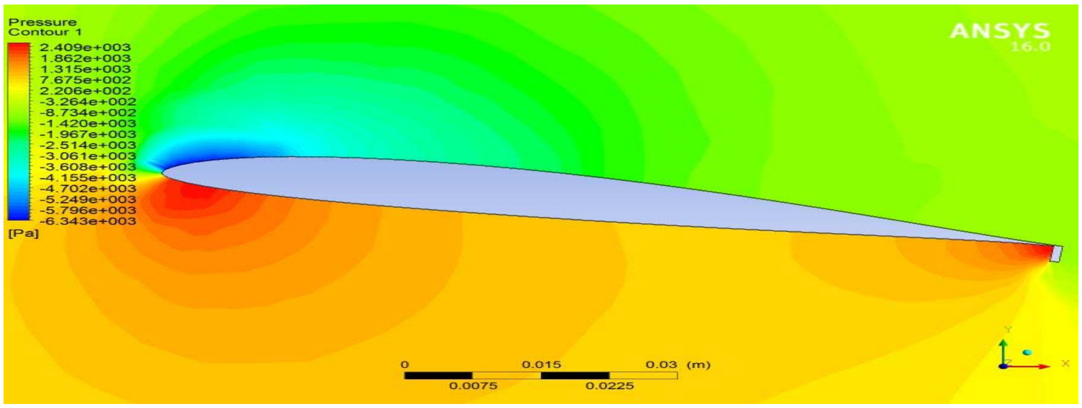

Figure 12: Pressure contours at 8 degree of angle of attack with 3% of gurney flap

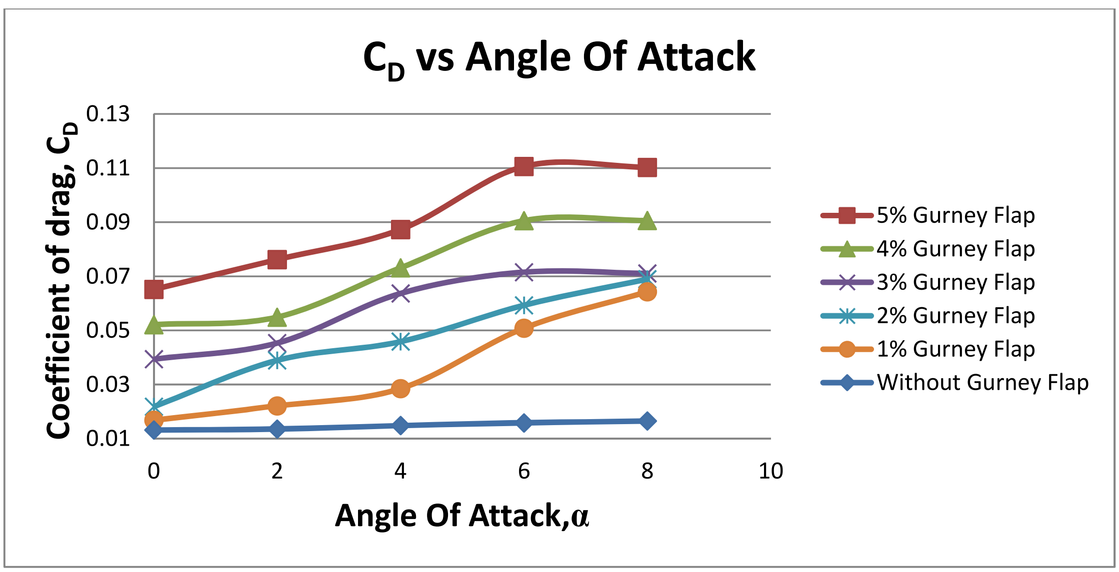

Figure 13: C_D vs Angle Of Attack

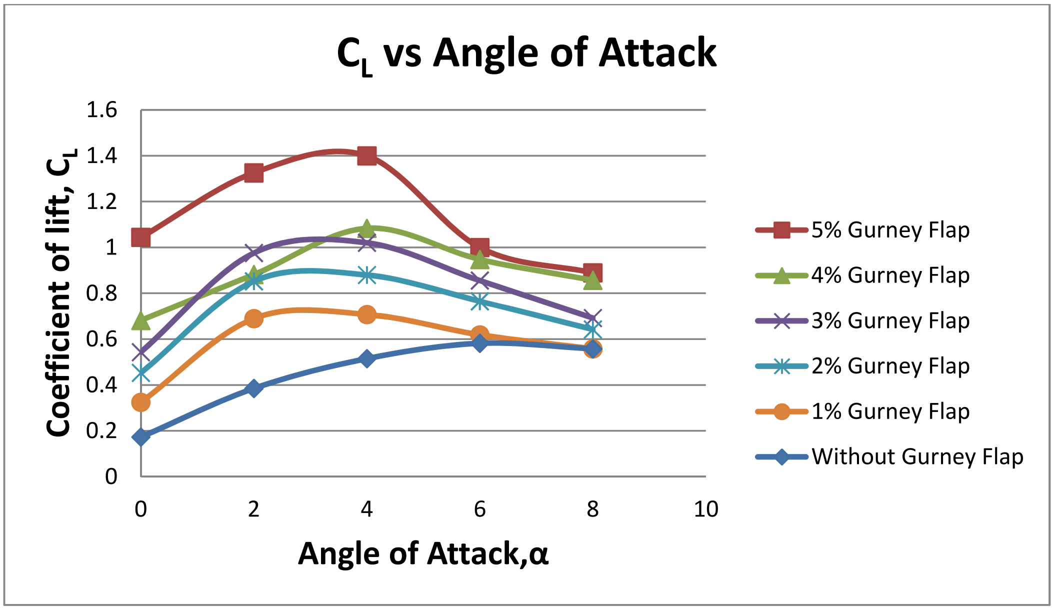

Figure 14: C_L vs Angle of Attack

IV DISCUSSIONS

All the results in this project in this project for NACA S6061 aerofoil are performed for fixed Reynolds number of 500000. The computational study is done for 0, 2,4,6 and 8 degree of angle of attack. From the graph and pressure contours of aerofoil without and with gurney flap at height ranging from 1% to 5% of chord length with increment of I %, it is observed that the value of coefficient of lift and coefficient of drag is changing at different angle of attack and also by varying the height of flap. Attaching gurney flap at the trailing edge of aerofoil increases the pressure difference between upper side and lower side of the aerofoil, this pressure affects the value of coefficient of lift and coefficient of drag of aerofoil. Typically for better performance of an aerofoil, the drag coefficient value of aerofoil should not exceed beyond 0. 04, thus in this project through computational fluid dynamics on ANSYS FLUENT, it was found that the optimum height of gurney flap at which the value coefficient of drag is less than or equal to 0.04 for different angle of attack. For zero degree angle of attack, the Gurney flap of height of 3% of chord length has coefficient of drag value of 0.03893 and coefficient of lift value is 0.54, there is 54 % of increment in lift coefficient compared to clean aerofoil, thus for zero degree angle of attack, the flap height should be kept below 3% of chord length. Now for 2 degree angle of attack, the optimum value of gurney flap is 2% of chord length, at 2 % the value of drag coefficient is 0.38 and the value of coefficient of lift is 0.88, there is 56 % of increment in lift, therefore for 2 degree angle, the length of gurney flap should be kept between 2% and 3 % of chord length. Similarly for 4 degree angle of attack, the length of gurney flap should kept between 2% to 3%. But from computational results, it is observed that the value of coefficient of drag is advancing beyond 0.06 and continuing, and also there is non-linear increment in the value of lift coefficient and drag coefficient. Thus for higher angle of attack the height of gurney flap should be kept minimum or avoid attaching gurney flap at trailing edge because of increment in drag values.

V CONCLUSION

NACA S6061 aerofoil with gurney flap has larger lift and drag coefficient than the clean NACA S6061 aerofoil at 0, 2, 4, 6 and 8 degree angle of attack considered. Use of gurney flap increases lift coefficient, however these increments are non-linear with respect to flap height. There is no significant increase in drag if height of flap is kept between 1% to 3%,but beyond this limit along with lift the drag also increases considerably. Also it is observed that with increase in angle of attack, the lift and drag coefficient are increasing significantly.

VI REFERENCES

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