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FLOW ANALYSIS OF KITE SHAPED WING DESIGN

T. Vijayalakshmi*, K. Suguntham, M. Yogananth

[*] Assistant Professor Department of Aeronautical Engineering, Hindusthan Collage of Engineering and Technology, Coimbatore, India

UG scholar Department of Aeronautical Engineering, Hindusthan Collage of Engineering and Technology, Coimbatore, India

UG scholar Department of Aeronautical Engineering, Hindusthan Collage of Engineering and Technology, Coimbatore, India

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ABSTRACT

The original idea was to figure the aerodynamics of kite and implementing the outcomes in the aircraft wing as the kite shapes possess very good aerodynamic property and more flow attachment is observed in it.The discussion is made on various types of kite shapes, from the discussion we have chosen hexagon shape as a model because the tip region is uniform so the flow attachment is more and the tip vortices generation is very low on comparing to other shapes by this shape the wing has to be modified .Airfoil NACA0021 is selected for drafting the wing design .The CATIA model is drawn for the wing designs using CATIA v5 .The model is then meshed with the HYPERMESH on the selected boundary condition.Then the model is analyzed using ANSYS FLUENT with a cruising speed of 240m/s at various angle of attack such as -12,-5,0,5,12 and the result is taken as different cases. From the results a comparison is made between the modified wing to the normal wing .The ultimate aim is to point out that the flow separation in hexagon wing for both airfoils reduces so that there is more lift generation than normal wing.

INTRODUCTION

A kite is traditionally a tethered heavier-than aircraft with wing surfaces that react against the air to create lift and drag. A kite consists of wings, tethers, and anchors. Kites often have a bridle to guide the face of the kite at the correct angle so the wind can lift it. A kite's wing also may be so designed so a bridle is not needed; when kiting a sailplane for launch, the tether meets the wing at a single point. A kite may have fixed or moving anchors. Untraditionally in technical kiting,a kite consists of tether-set-coupled wing sets ; even in technical kiting ,though, a wing in the system is still often called the kite.

The lift that sustains the kite in flight is generated when air flows around the kite's surface, producing low pressure above and high pressure below the wings. The interaction with the wind also generates horizontal drag along the direction of the wind. The resultant force vector from the lift and drag force components is opposed by the tension of one or more of the lines or tethers to which the kite is attached.

Kites are most commonly created with lightweight material covering a flexible frame. The lightweight material helps to minimize weight, which makes it easier for the kite to create the necessary lift to fly. The flexible frame lets the kite bend to the optimal shape for flying. An unbending kite would more resemble a flat plate than an airfoil. With the curved airfoil shape, the kite is much more able to produce lift. The angles of the strings also play a very important role in deciding how a kite flies. The strings decide how the wind will strike the kite, and what its angle of attack will be.

The forces that act on the kite are lift, drag, and gravity. In order to fly, a kite needs a steady stream of flowing air. This wind, when incident on the frontal surface of the kite flows around the kite, thereby producing lift. There is hence a stagnation point on the frontal surface of the kite, where the pressure is a maximum. The wind also causes a resistive force on the kite, which is basically the drag force, and it is a combination of these forces that keeps the kite in the air. The point of maximum pressure is also the point through which these forces act through, and it is thus known as the center of pressure. Not surprisingly, this is the point where the string is tied and it is commonly known as the tow point. The overall forces on the kite are balanced by the force of the tension along the string of the kite.

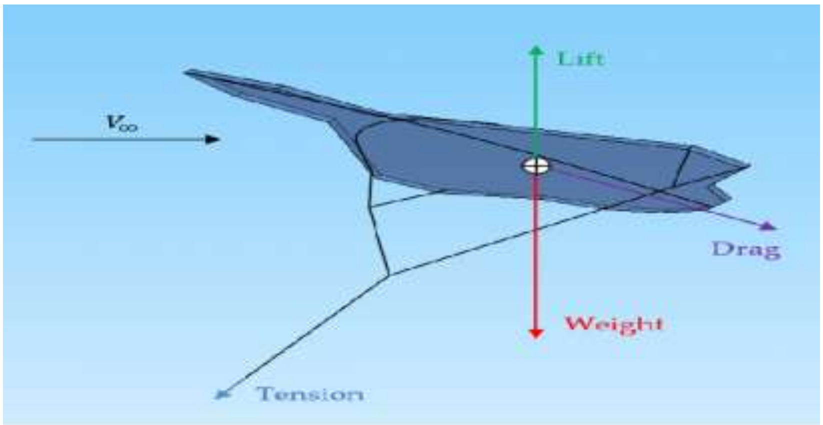


Figure.1 Forces on kite

DESIGN CALCULATION

The design parameters are taken from the reference of a business jet cj139[5]:

Root chord = 10.7m
Tip chord = 2.14m
Semi span = 17m
Sweep angle = 30^0
Surface area =$108.8m^2$
Tapper ratio = 0.2
Reynolds no =$0.9*10^{10}$
Mach no = 0.72
Velocity =240m/s

Airfoil selected

NACA 0021

The two airfoils chosen are one from symmetrical and unsymmetrical which are used in aircraft cj139 and the they have stalling AOA of 15 and posses good aerodynamic property.

MODELING OF HEXAGON WING

The co-ordinates of the airfoils chosen NACA0021 and were collected, which is useful to draw the wing sections in CATIA software by importing the co-ordinates to it.

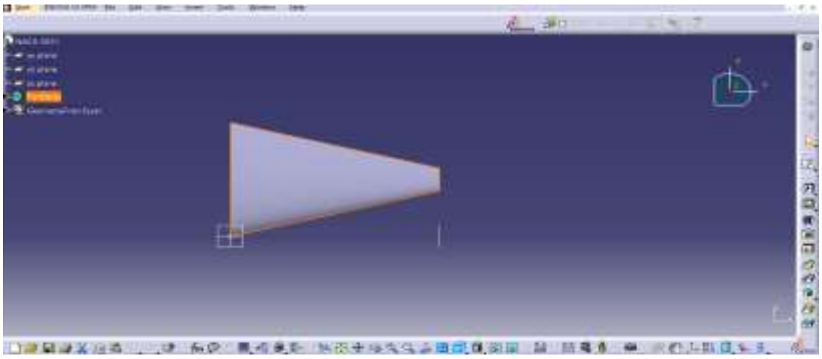


Figure.2. a)hexagon wing(NACA0021) top view

MESHING

After drawing the 3-D diagram of the wing, they are imported to HYPERMESH as iges files. In HYPERMESH the 3-D diagram is properly divided into separate elements and also by allocating the boundary conditions of inlet,outlet and sidewalls. The meshed files were saved properly and imported for solving the flow process.

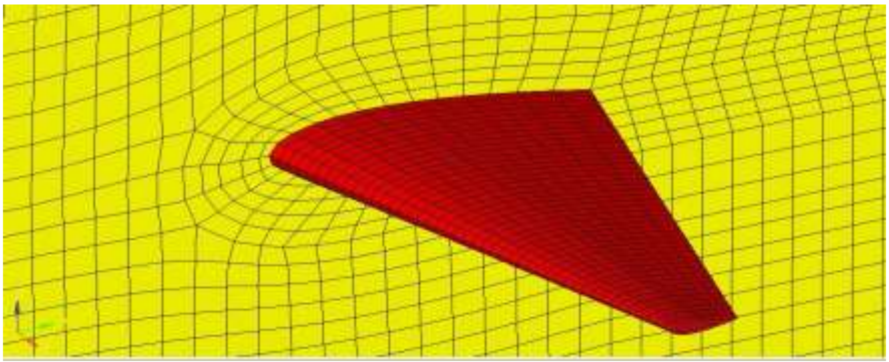


Figure.3.Meshing of hexagon wing No. of elements: 497536 Element size:100

SOLVER CONTROLS

After generating mesh it was feed to a solver to calculate the flow properties. Here the solver used was a FLUENT. ANSYS FLUENT is a state-of-the-art computer program for modeling fluid flow, heat transfer and chemical reactions in complex geometries.

Inlet conditions:

Velocity =240 m/s
Temperature =216.65k
Pressure =93990 N/m2
Altitude =12km
Density =53.3m3
Fluid = Ideal gas
No.of Iteration =1000
Iterations are converged
Forces monitored:lift,drag

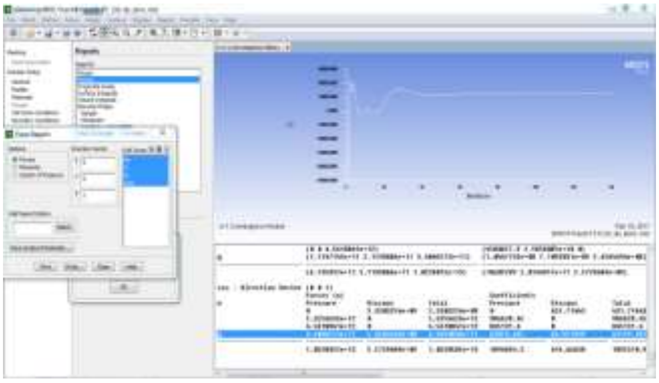
RESULT & DISCUSSION

The results of the various analysis is shown which consists of pressure contour,pressure plot,lift and drag values of four different wing designs two normal wings and two hexagon wings of airfoils NACA0021.

CFD ANALYSIS OF NORMAL WING(NACA0021)

Lift

The lift value of the normal wing at various angle of attack is shown below in which the maximum lift produced in 12^0 of about 120.78kN and minimum value is produced at 0^0 of about 3.68kN.



b) 5^0 AOA

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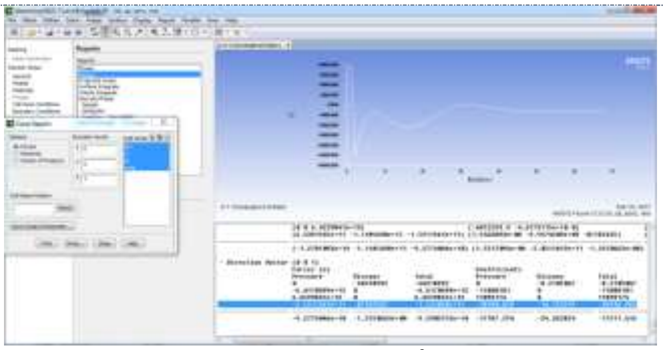
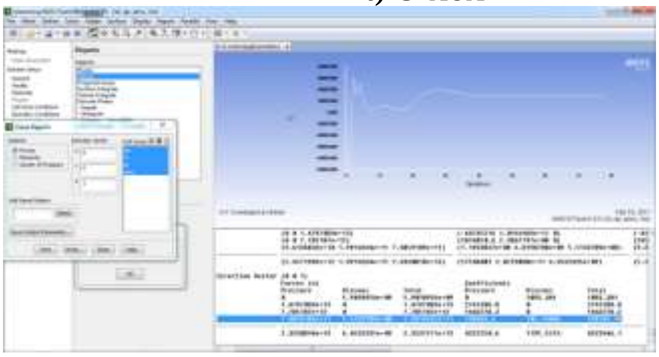
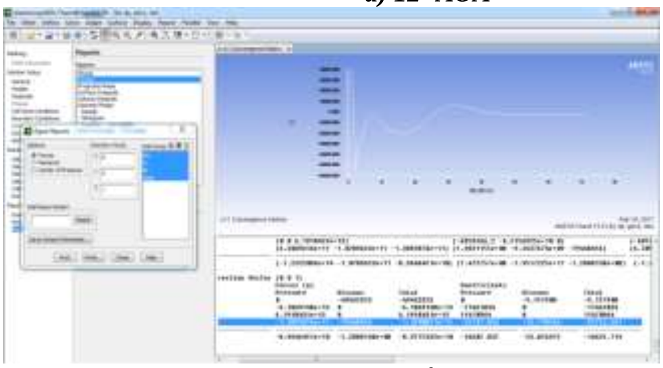


c) -5⁰ AOA



d) 12⁰ AOA

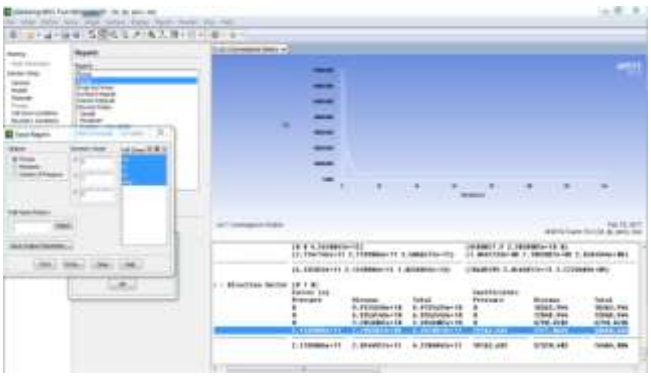


e) -12⁰ AOA

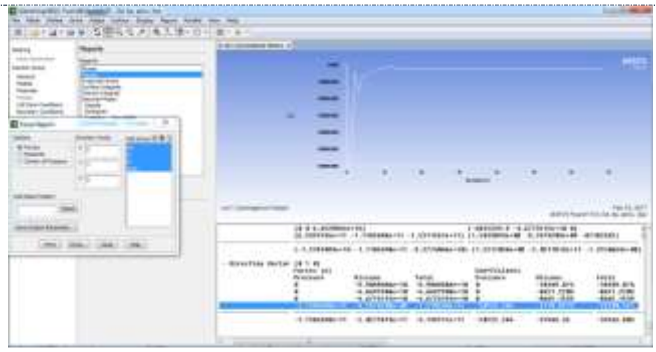
Fig.4.(a,b,c,d,e) Lift for normal wing(NACA0021)

Drag

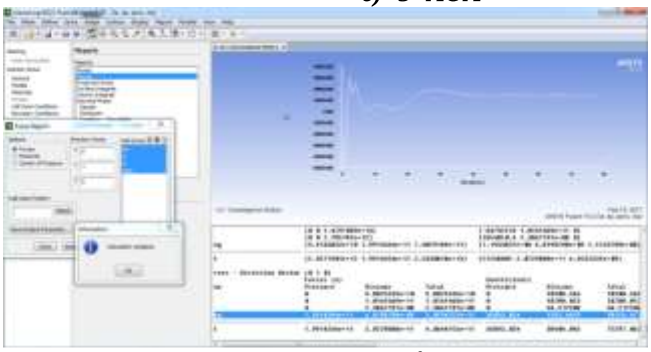
The drag formed in the normal wing the various angle of attack is shown below in which the maximum drag is produced at 0^0 of about 41.18kN and minimum value is produced at-5^0 of about 21.78kN.



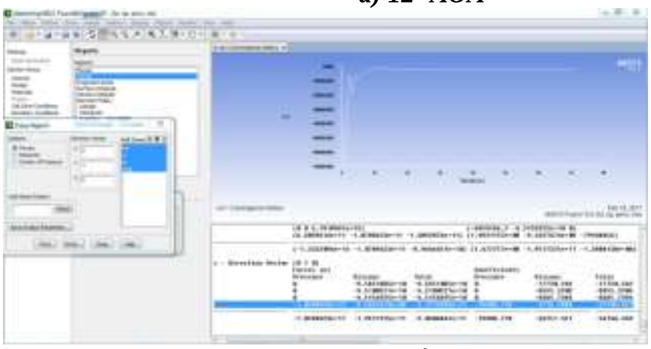
b) 5⁰ AOA



c) -5^0 AOA



d) 12^0 AOA



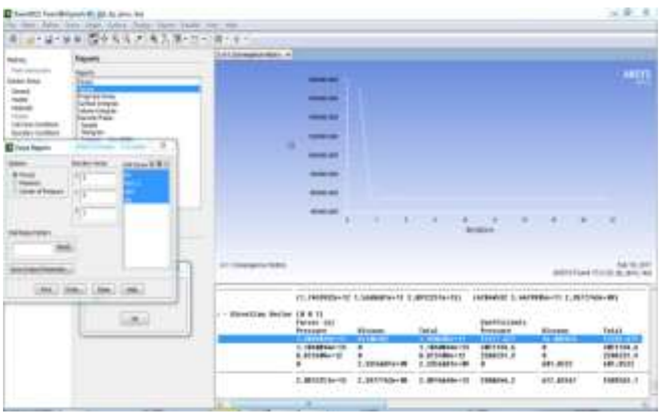
e) -12^0 AOA

Fig.5.(a,b,c,d,e) Drag for normal wing(NACA0021)

CFD ANALYSIS OF HEXAGON WING(NACA0021)

Lift

The lift value of the normal wing at various angle of attack is shown below in which the maximum lift produced in 12^0 of about 123.14kN and minimum value is produced at 0^0 of about 5.75kN.



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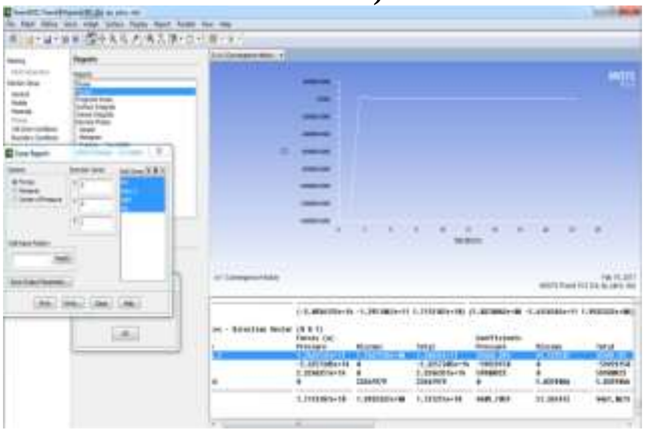
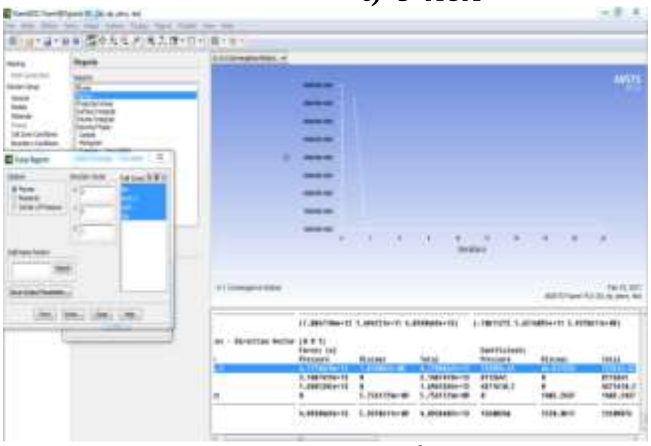
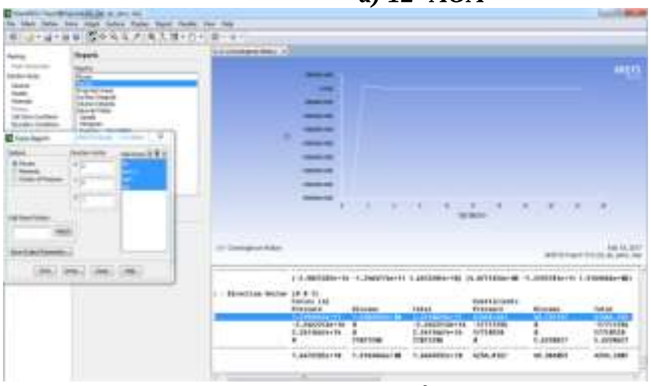
b) 5^0 AOA



c) -5^0 AOA



d) 12^0 AOA



e) -12^0 AOA

Fig.6.(a,b,c,d,e) Lift for Hexagon wing(NACA0021)

Drag

The drag formed in the normal wing the various angle of attack is shown below in which the maximum drag is produced at 0^0 of about 41.12kN and minimum value is produced at -12^0 of about 33.46kN.

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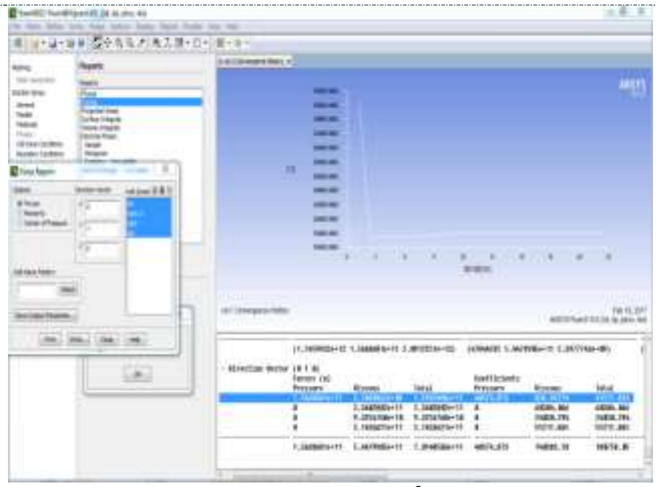
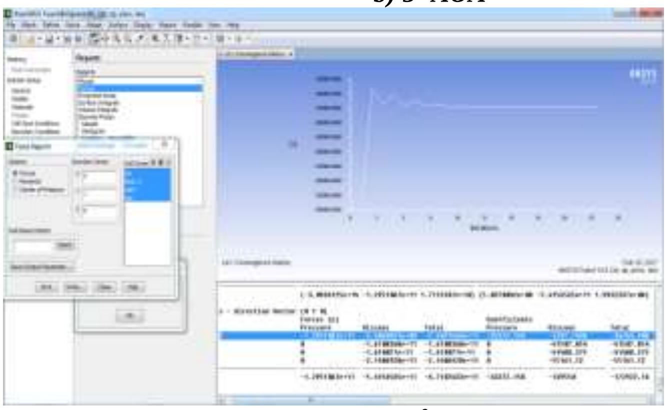
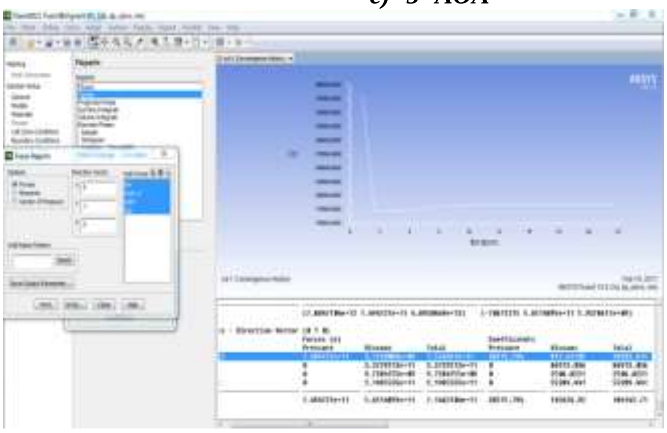


b) 5^0 AOA



c) -5^0 AOA



d) 12^0 AOA

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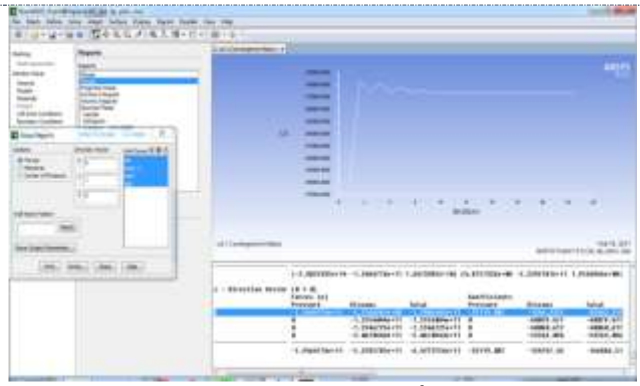

e) -12⁰ AOA

Fig.7.(a,b,c,d,e) Drag for Hexagon wing(NACA0021)

Co- efficient of Lift for All Angles

The co-efficient of lift versus angle of attack for the normal wings and hexagon wings model studied in the investigation are shown.from the table and the graph it is observed that the lift increases with increase in angle of attack and the hexagon wing(NACA0021) has more lift when compared to other wing models.

Table.1 Coefficient of lift

Sl.no	AOA(⁰)	Normal wing(NACA0021)	Hexa wing(NACA0021)	Normal wing(NACA2412)	Hexa wing(NACA2412)
1.	-12	0.027	0.033	0.0131	0.013
2.	-5	0.029	0.034	0.0136	0.084
3.	0	0.0039	0.006	0.01	0.02
4.	5	0.046	0.05	0.043	0.013
5.	12	0.127	0.13	0.11	0.103

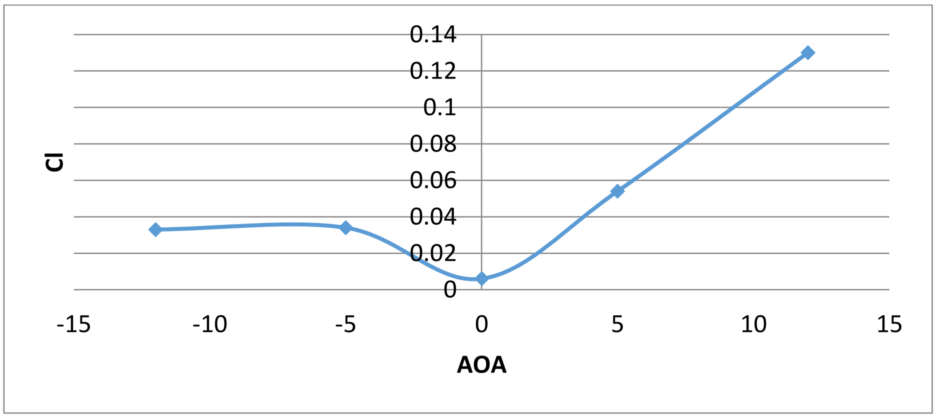

Figure.8.AOA VS C_l of hexagon wing(NACA0021)

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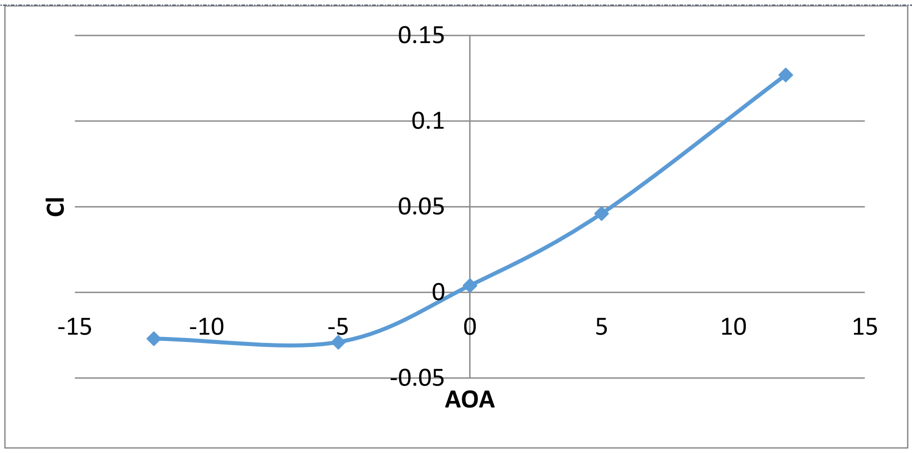

Figure.8. AOA VS C_l of normal wing(NACA0021)

CONCLUSION

The hexagon wing(NACA0021) shows better results on comparison made with the normal wing, that is it generates more lift in any angle of attack when compared to normal wing.The lift produced by hexagon wing(NACA0021) is 5.8% more than the normal wing(NACA0021).A graph is plot between the angle of attack and the co-efficient of lift for both normal wing and hexagon wing it shows that hexagon wing has more lift than normal wing.The drag produced is also low when compared to the normal wing. Another graph is also plot between the angle of attack and co-efficient of drag,it shows the better results about the hexagon wing.From the results of analysis it is justified that there is more flow attachment in the hexagon wing when compared to normal wing so that we can increase the lift and reduce the pressure drag formed.

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