International Journal of Innovative Studies in Sciences and Engineering Technology (IJISSET)

ISSN 2455-4863 (Online) www.ijisset.org *Volume: 2 Issue: 5 | May 2016*

Comparative Analysis of Various Vortex Generators for a NACA 0012 Aerofoil

G.Vasantha Kumar[1], K.Sathiya Narayanan[2], S.K.Aravindhkumar[3], S.KishoreKumar[4]

[1,2,3,4] Student, Department of Aeronautical Engineering, Sri Shakthi Institute of Engineering and Technology, Tamil Nadu, India

Abstract: *The Comparative analysis of various shapes of vortex generator is the main objective that is carried out in this paper. Here we had taken different shapes like rectangle, triangle, and gothic shapes for the comparative analysis and results based on different angle of attack at 0° and 10°. This detailed study is carried out on the NACA 0012 symmetric airfoil. The main causes of aerodynamic drag is the separation of flow near the aerodynamic object's rear end. To control the flow separation we place a device known as vortex generator. A vortex generator is an aerodynamic device, it removes the slow moving boundary layer by energizing the slow moving layer and modifies the flow around the surfaces affecting boundary layer and controlling the flow separation. From the above mentioned shapes, we determine the drag force values and drag coefficient values to find the best result of various Vortex Generator. Various Shapes, which is designed by Computer Aided Design in CATIA V5 software. Drag Force values can be obtained by using output of CFX. Besides that, CFX simulation results of streamline flow at the rear end of NACA 0012 is also obtained. Boundary conditions are given to the ansys analysis at the inlet and outlet as a default domain. Models are analysed in two different angles for comparing the best shape at the given condition at different angle of attack. Comparison of drag coefficient values of the Various Shapes of vortex generator is done and the most efficient shape is give in this comparative analysis study.*

Keywords: *Boundary layer, Flow separation, vortex generator, Drag force and Drag coefficient.*

1. INTRODUCTION

A vortex generator is an aerodynamic device, attached to anaerodynamic surface. When the airfoil or the body is in motion relative to the air, the vortex generators creates a vortex, which, by removing some part of the slow-moving boundary layer in contact with the airfoil surface, delays local flow separation and aerodynamic stalling, thereby improving the effectiveness of wings and control surfaces.

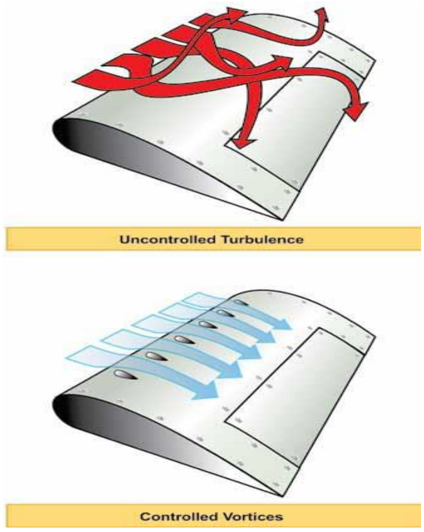

Fig 1: *Working of vortex Generator*

The Best solution to avoid separation is to use Vortex generators. Each of these small elements creates a swirling wake that places energy in the boundary layer of the wing. The result is a higher critical angle of attack, a lower stall speed and gentle stall characteristics. The vortex generators affect boundary layer in the flow around the airfoil. Turbulent boundary layer is more resistant to separation. In this way it is possible to fly at a slower speed and higher angles of attack. Vortex Generators on stabilizers act similarly improving the effectiveness of control at low speeds and with high deflections of control surfaces. Proper location of vortex generators is very important. They should be positioned precisely in the transition region of the boundary layer.

Situation is somewhat complicated by the fact that transition region, depending on the flow conditions and angle of attack, changes its position. If Vortex generators will be too close to the leading edge - will be in the laminar boundary layer and cause excessive drag during cruise, but if they are too far from the leading edge -their effectiveness at high angles of attack and low flight speed may be affected. The optimal mounting location can be determined by computer simulations, wind tunnel testing or during test flights.

ISSN 2455-4863 (Online) www.ijisset.org Volume: 2 Issue: 5 | May 2016

2. NACA 0012 AIRFOIL

Function of the wing is to generate lift force. The NACA airfoils are airfoil shapes for aircraft wings developed by the National Advisory Committee for Aeronautics (NACA). The shape of the NACA airfoils is described using a series of digits following the word "NACA".

Example: The NACA 0012 airfoil is symmetrical, the 00 indicating that it has no camber. The 12 indicates that the airfoil has a 12% thickness to chord length ratio, it is 12% as thick as it is long.

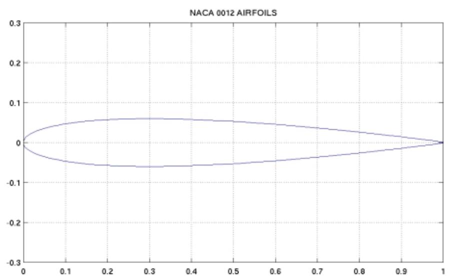

Fig 2: *NACA 0012 airfoil*

3. DESIGN CONSIDERATIONS

A. Shape of the Vortex Generators

There are many types of Vortex Generators being used on aircrafts as shown in Fig. 3. Out of these shapes gothic, triangular and rectangular vortex generators are considered for comparison.

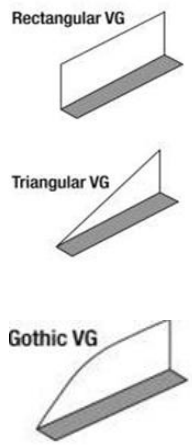

Fig 3: *Various Shapes of Vortex Generators*

4. DIMENSIONS OF VORTEX GENERATOR

The Following values like height, length, thickness, position of vortex generator are considered from the reference study.

1.Rectangular Vortex Generator

Table 1: *Rectangular vortex generator dimension*

LENGTH	80mm
HEIGHT	90mm
THICKNESS	20mm

2.Gothic Vortex Generator

Table 2: *Gothic vortex generator dimension*

LENGTH	80mm
HEIGHT	90mm
FILLET RADIUS	70.42mm
THICKNESS	20mm

3.Triangular Vortex Generator

Table 3: *Triangular vortex generator dimension*

LENGTH	80mm
HEIGHT	90mm
THICKNESS	20mm

The Position of all the above shapes are fixed at 16% of the chord length from the leading edge, because at that point the transition region occurs from laminar to turbulent.

5. WING DESIGN PARAMETERS

Aspect ratio = 6.85

Wing area =63.21m2

Wing span =21.04m

Chord Length=1m

Wing loading=182.69 kg/m2

CAD DESIGN

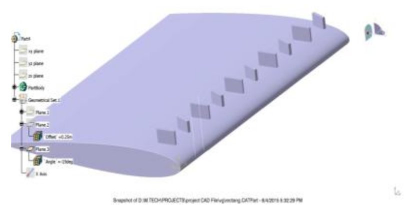

Fig 4: *CAD Design of Rectangular Vortex Generator*

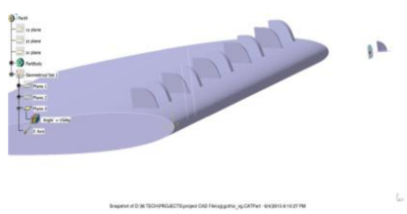

Fig 5: *CAD Design of Gothic Vortex Generator*

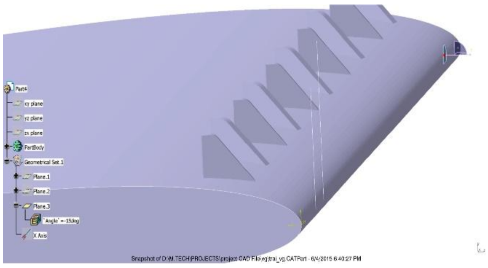

Fig 6: *CAD Design of Triangular Vortex Generator*

Boundary Conditions

Table 4: *Inlet Outlet Boundary Condition*

Type	Fluid
Domain Motion	Stationary
Reference Pressure	1 atm
Fluid Temperature	25°C
Flow Regime	Subsonic
Normal Speed	250 m/s
Mass and Momentum	No Slip Wall
Wall Roughness	Smooth Wall

6. COMPARISION OF DRAG FOR VARIOUS VORTEX GENERATOR SHAPES AT 0° ANGLE OF ATTACK

A. Drag Value For Rectangular Vortex Generator

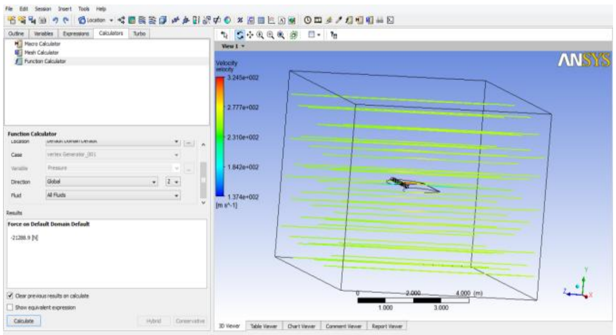

Fig 7: *Drag Force for Rectangular Vortex generator at 0° (D= 21288.9 N)*

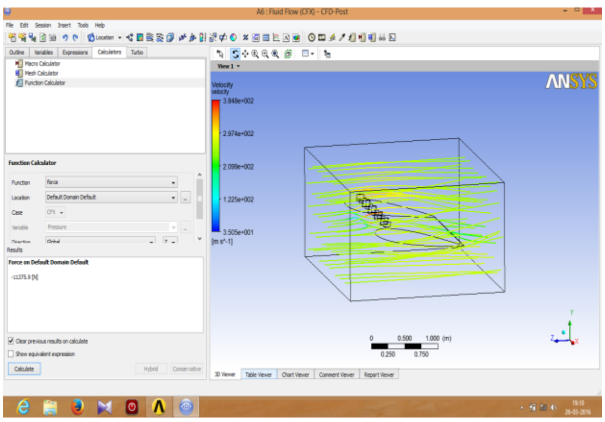

Fig 8: *Drag Force for Rectangular Vortex generator at 10° (D= 11375.9 N)*

B. Drag Value For Gothic Vortex Generator

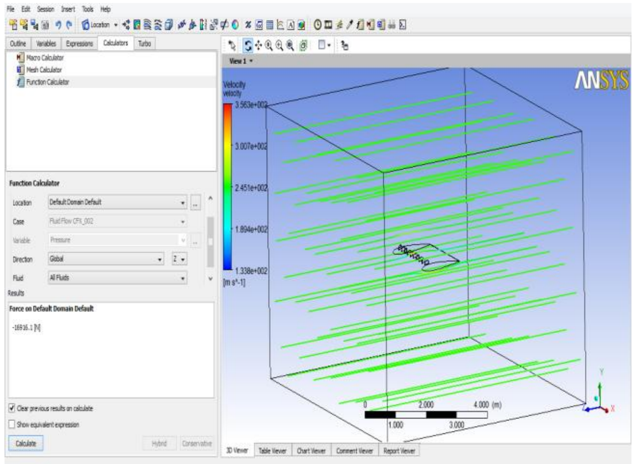

Fig 9: *Drag Force for Gothic Vortex generator at 0° (D= 16916.1 N)*

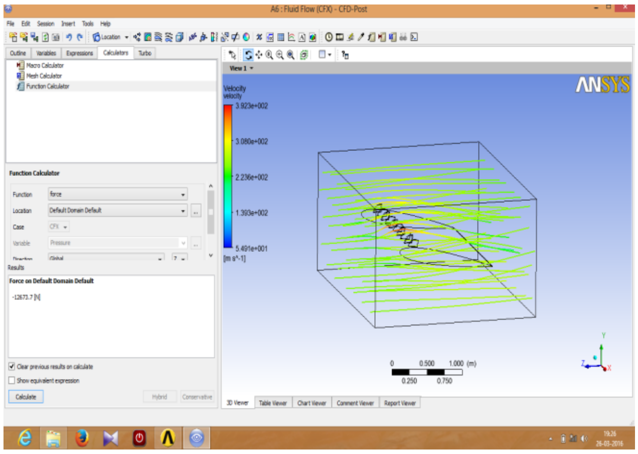

Fig 10: *Drag Force for Gothic Vortex generator at 10° (D=12673.7 N)*

C. Drag Values For Triangle Vortex Generator

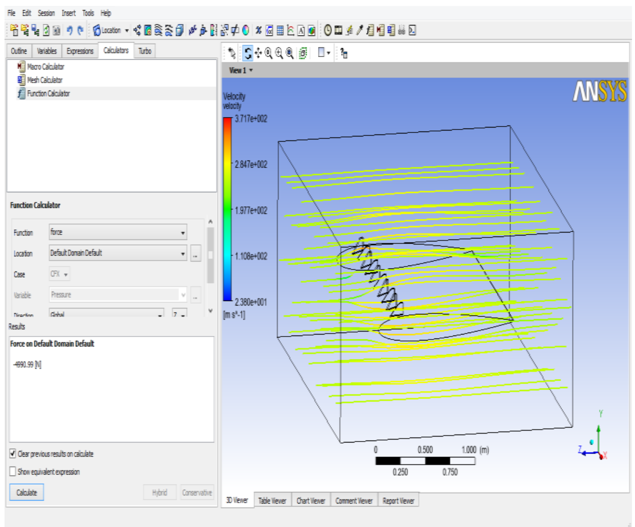

Fig 11: *Drag Force for Triangular Vortex generator at 0° (D= 4990.99 N)*

International Journal of Innovative Studies in Sciences and Engineering Technology (IJISSET)

ISSN 2455-4863 (Online) www.ijisset.org *Volume: 2 Issue: 5 | May 2016*

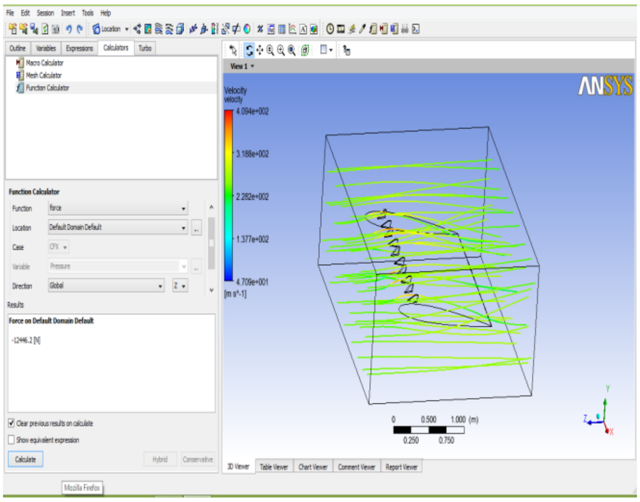

Fig 12: *Drag Force for Triangular Vortex generator at 10° (D= 12446.2 N)*

7. CONCLUSION

In aerodynamics, flow separation can often result in increased drag, particularly pressure drag which is caused by the pressure differential between the front and rear surfaces of the object as it travels through the fluid. For this reason much effort and research has gone into the design of aerodynamic and hydrodynamic surfaces which delay flow separation and keep the local flow attached for as long as possible. In this project we used different shapes of vortex generator, and delayed the flow separation. The drag force values for all shapes of vortex generators were found and the results were compared.

Table 5: *Drag Force and Drag Coefficient comparison for 0°*

Sl.No	Vortex Generator Shapes	Drag force at 0° AOA (N)	Drag Coefficient
1	Rectangular	21,288.9	0.008797
2	Gothic	16,916.1	0.006990
3	Triangular	4990.99	0.002062

Table 6: *Drag Force and Drag Coefficient comparison for 10°*

Sl.No	Vortex Generator Shapes	Drag force at 10° AOA (N)	Drag Coefficient
1	Rectangular	11375.9	0.004701
2	Gothic	12673.7	0.005237
3	Triangular	12446.2	0.005143

The Analysis result gives the comparative values of various vortex generators. These shapes gives a value of less drag force comparatively with rectangular, gothic, triangular vortex generator from 0.008797 to 0.006990 to 0.002062 at 0° Angle of Attack. At 0° Angle of Attack triangular vortex generator gives the best drag reduction comparing other two shapes. At 10° Angle of Attack there is some changes in the drag value where the rectangular vortex generator gives the small reduction in drag coefficient. The Comparative results are tabulated with the corresponding drag force value and their drag coefficient values respectively.

According to our analysis, the Triangular Shape vortex generator gives minimum amount of drag force and also delays flow separation through increasing velocity near the surface.

REFERENCES

[1] H. Tebbiche, and M.S. Boutoudj,"Optimized vortex generators in the flow separation control around a NACA 0015 profile,"International Conference on Structural Dynamics, EURODYN 2014.

[2] David Joseph Ronald Tucker, "An Experimental Study of Hemispherical Vortex Generators for Separation Control over a NACA 0012," Master Thesis, Dec. 2013.

[3] P. T. Soderman, "Aerodynamic Effects of Leading-Edge Serrations on a Two-Dimensional Airfoil," United States, 1972.

[4] Anderson D. John, Jr. 'Fundamentals of aerodynamics', Edition V, McGraw-Hill Book Company, 1984.

[5] Masaru koike, Tsunehisanagayoshi, and Naokihamamoto "Research on Aerodynamic Drag Reduction by Vortex Generators,"2004.

[6] "UIUC Airfoil data site" for the coordinates of NACA 0012 Symmetric Airfoil.

