Numerical Analysis on how Vortex Generators help in delaying the stall

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1. INTRODUCTION & OBJECTIVE

A vortex generator (VG) is an aerodynamic device, consisting of a small vane attached to a lifting surface (or airfoil, such as an aircraft wing). When the airfoil or the body is in motion relative to the air, the VG 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, such as flaps, elevators, ailerons, and rudders.

1.1. Design of Vortex Generator

The Vortex Generator should be placed just in front of the laminar to turbulent transition of the boundary layer on the wing. This transition point is located at approximately 16% back on the wing chord from the leading edge[1].We took the chord length as 1 meter. The length of the Vortex Generator should be around 5-8% of the chord length of the wing. We have made the vortex generators have a height of 1/8th of an inch to make them easier to handle.

This analysis compares 3 different types of vortex generators, i.e, rectangular, triangular and gothic over an airfoil (NACA 2412). We run this analysis in ‘ansys fluent’. First, the design is made using design modeler (with the c-flow domain), then meshing is done using the edge sizing method at required edges, and finally the boundary conditions are applied, i.e., velocity, density and angle of attack. After which we obtain the lift and drag coefficient along with the velocity and pressure contours.

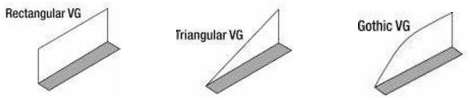


Fig. 1 Different shapes of VG[1]

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

As expected from our literature survey[2], the vortex generators energise the flow of the moving air and delay the stall, if any. These are the readings of lift coefficient with respect to angle of attack we got at different angles of attack from our 2-D CFD analysis in Ansys software. We can observe in the figures above that vortex generators help delay stall. Also from these graphs, we can say that triangular vortex generators act as the best vortex generators in delaying the stall. The gothic vortex generator gives an increase in the lift coefficient but stalls early. So, different shapes of vortex generators can be used to get the desired result.

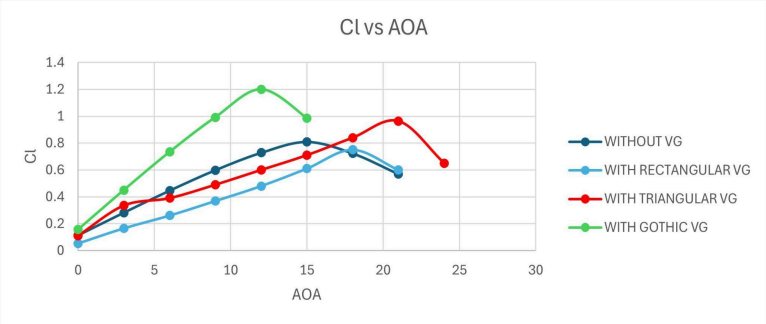
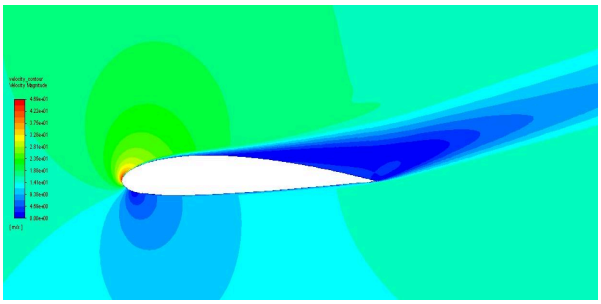
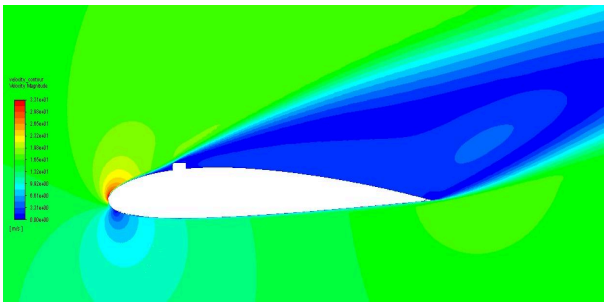


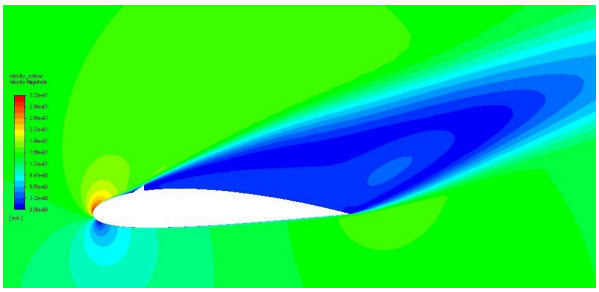
Fig. 1. Lift Coefficient vs Angle of Attack



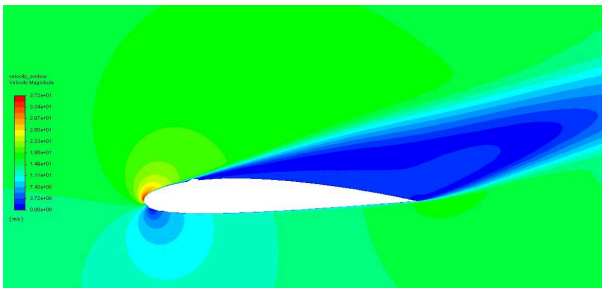
(a) Wing without the vortex generator



(b) Wing with the rectangular vortex generator



(c) Wing with the triangular vortex generator



(d) Wing with the gothic vortex generator

Fig. 2. Velocity contours at 18 deg angle of attack

It may seem in these diagrams of the wing with vortex generators, Fig.2 (b) and (c) that flow separation is occurring, but it is actually the vortices, and there is some light blue shade close to the boundary of the top of the airfoil which denotes that the flow is not separated yet. It is seen that the airfoil, without vg, Fig.2 (a) and with gothic vg Fig.2 (d) stalls, since it just acts like a small camber.

REFERENCES

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2. Naveen Janjanam, K. Raja Babu, S.S. Chowhan, Abid Khan, M. Teja, *Comparison of NACA 23024 Aerofoil with and Without Vortex Generators Using CFD*, International Journal of Mechanical Engineering and Technology, 8(5), 2017, pp. 556- 566.