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# Lab Development and Modelling of Vortex Generation System, by Implementing Vortex Generators

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**ABSTRACT:** When the wing exceeds its critical angle of attack, the airfoil becomes turbulent and breaks away from the airfoil and lift decreases rapidly. Vortex generator delays the separation through higher angle of attack. These VG's create their own vortices. These swirls of air energize the layer of air immediately above the wing's surface and cause the air to remain attached to the airfoil longer as angle of attack increases.

**KEYWORDS** - critical angle, turbulent, airfoil, vortex generator, lift, vortices.

## I. INTRODUCTION

In the aviation industry VGs are a widely used device to control the flow over part of the blades. The application of VGs to limit flow separation has a long history, originating from the work of Taylor where rectangular type VGs were applied to limit flow separation. In connection with wind energy applications one of the early references is the work on the MOD-2 rectangular VGs by Sullivan where an 11% increase in annual energy production was reported.

Due to the large range of scale present for a wing equipped with VGs, it is not computationally feasible to directly attack the problem using a full rectangular VGs blade equipped with a large number of VGs (typically in the order of 100 of VGs). Two approaches have forces as in the rectangular type of models by modelling the boundary layer mixing effect of the VGs by increasing the turbulence kinetic energy at the VGs position.

## II. METHODOLOGY

VGs create strong tip vortices which feed high energy air from the external stream to makes with or replace the slower moving air in the boundary layer and reduces the effects of adverse pressure gradients and prevents separation.

To observe this effect of VG, a setup of vortex generation is important to showcase and predict the effects of VG by placing it on different locations and parts of an aircraft (such as fuselage, wings, engine, nacelle, etc.) as well as analytically calculated its effects by plotting graphs for various angle of attack velocities, heights of VGs, camber of airfoil, different types of wing and fuselage shapes.

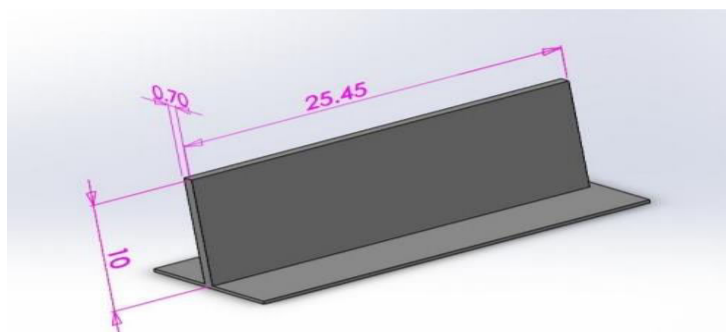


Fig 1: Dimension of Vortex Generator

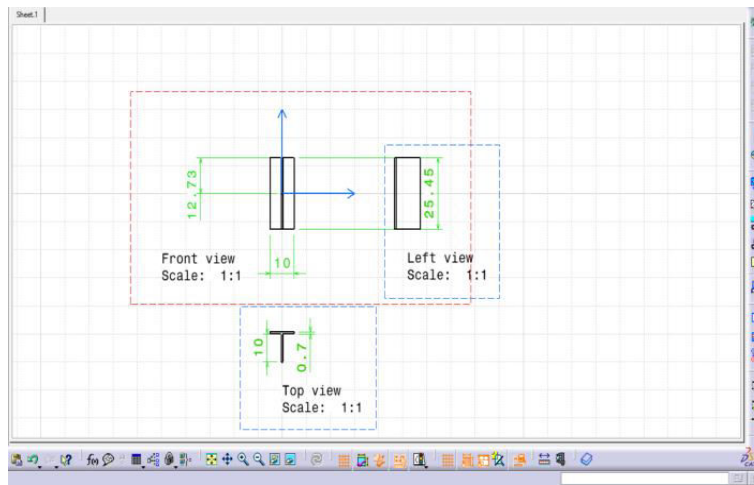


Fig 2: Design of Vortex Generator

1. APPROACHES

i. Qualitative Approach

- The vortex interacts with the boundary layer air on the air craft
- Surface behind the device by inducing high energy air from outside the boundary
- Layer down to the surface displacing flow energy air.

ii. Numerical Approach

$$C_{LmaxVG} > C_{Lmaxclean}$$

$$V_{stallVG} < V_{stallclean}$$

$$\sqrt{\frac{2W}{\rho S C_{LmaxVG}}} < \sqrt{\frac{2W}{\rho S C_{Lmaxclean}}}$$

2. DRAFTING IN CATIA

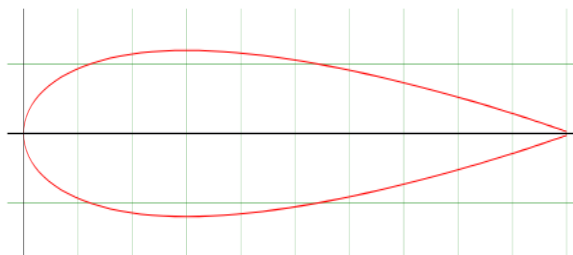


Fig 3: Drafting of Airfoil

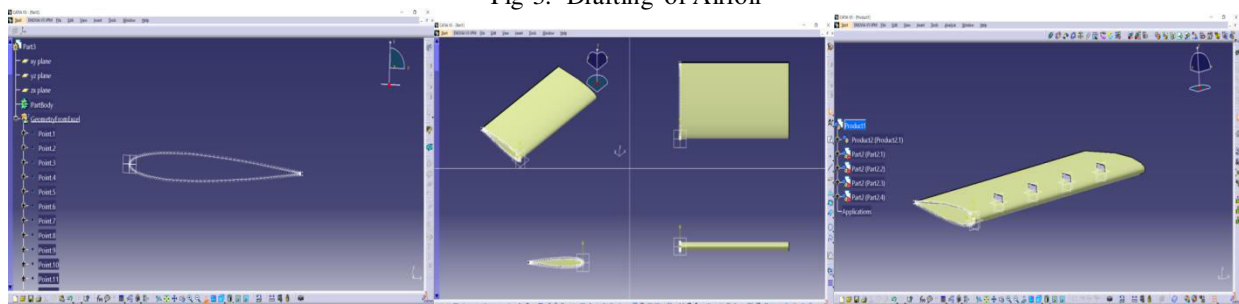


Fig 4 : Drafting of Airfoil in Catia



3. RELEVANT DATA

ALTO TG	912 ULS
Length of wing	6.15 m
Mean aerodynamic chord	1.315 m
Wing span	8.2 m
Fuel	110 L
Empty weight	288 kg
MTOW-ULM	450 kg
Cruising speed	200 km/h
Stall speed flaps up	75 km/h
Stall speed full flap	62 km/h
Take-off roll distance(grass)	120 m
Take-off roll distance(pav)	110 m
Landing roll distance	91 m

4. NACA 0012

Focused on during this project include that a symmetric airfoil does not generate lift at zero angle of attack. Since NACA 0012 is symmetric about its chord line i.e., at zero angle of attack there is no lift. Another fundamental principle is that lift is created over an airfoil by the pressure differences over the top and bottom surfaces of the airfoil. Drag over an airfoil is caused by drag due to lift (induced drag), skin friction, as well as pressure. The drag due to lift is caused by the tip vortices of the airfoil not extending to the walls of the rectangular VG and allowing the high pressure to interact with the relative low pressures along the top surface of the airfoil causing a loss in lift. The drag due to skin friction is due to the molecules passing over the surface in no slip condition. The pressure drag is created by the stagnation point in the front of an airfoil which impedes the flow of the fluid over the airfoil. This whole analysis is done at subsonic flow.

5. VELOCITY DIAGRAM

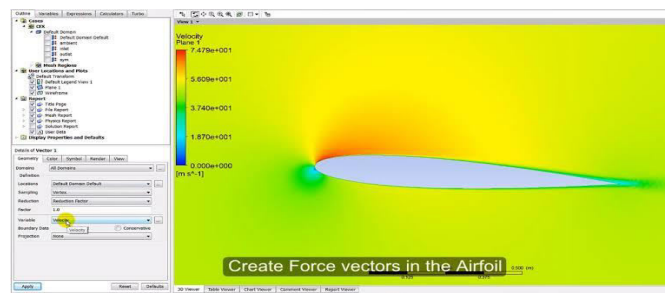


Fig 5: Without Vortex Generator

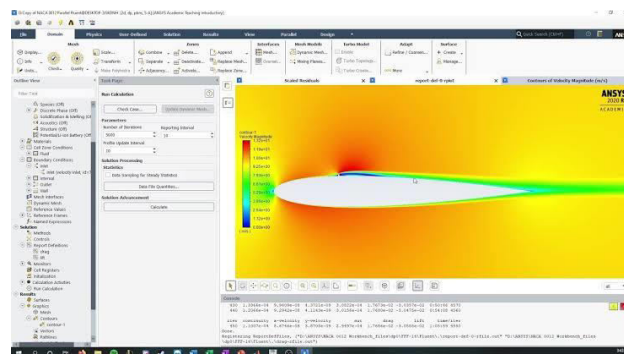


Fig 6: With Vortex Generator



6. SIMULATION

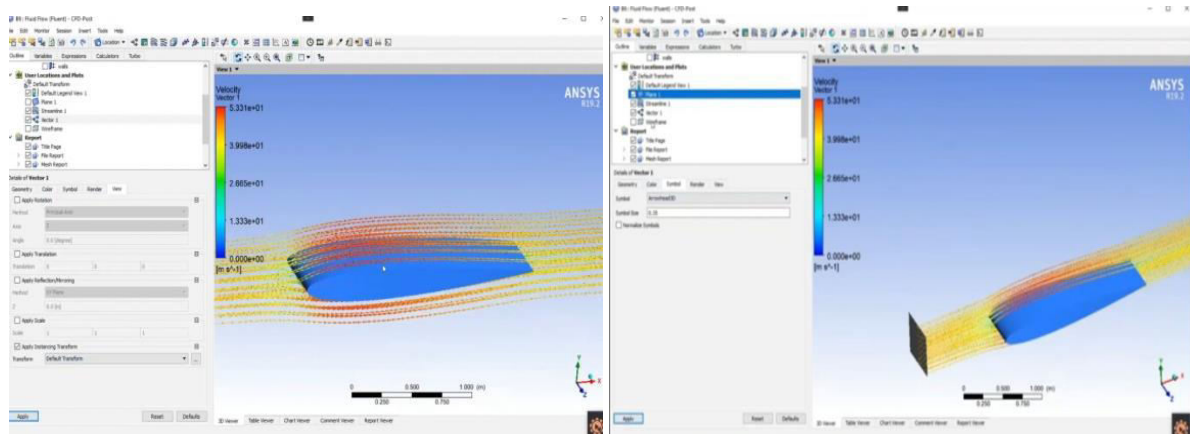


Fig 7: 3D Simulation of NACA 0012

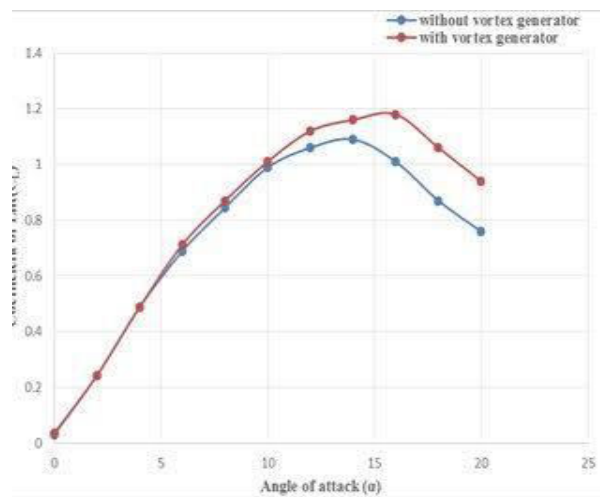


Fig 8: C<sub>L</sub> - α curve

III. RESULT

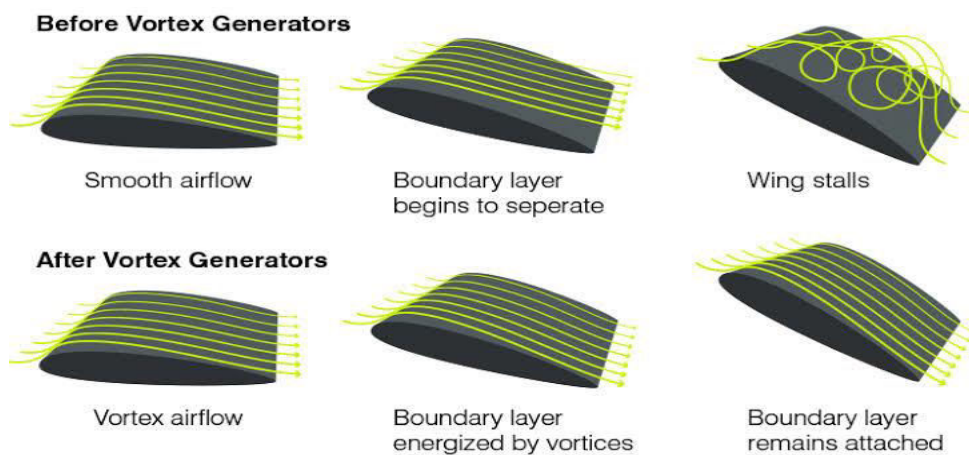


Fig 9: Theoretical Result (visual)



Angle of attack	CI 3D Simulation
0°	0,37
13°	0,65
15°	0,73
20°	0,86
25°	0,90

Table 1: 3D Simulation at given angle of attack

PROS AND CONS

- Pros:
  - Increases slope of lift curve
  - Increase in Gross Take-off weight
  - Stall speed reduction (7-21%)
  - Improved handling qualities
  - Decrease tire and brake wear
- Cons:
  - Expensive
  - Makes debugging of leading edge difficult
  - Possible source of vibration
  - Dual instruction and practice required for full effectiveness

IV. CURRENT RELEVANCE

The vortices persists many tense of generator heights downstream and the boundary layer is significantly thinned between the vortex cores in the common down configuration in which the bulk flow is ‘induced’ towards the surface by divergent pairs of VGs, that is in the same way as aircraft trailing vortices. At high angle of attack the vortex generator generates a powerful vortex that makes up for the flow separation and loss of lift due to the presence of the nacelle the strake typically has a leading edge sweep of approximately 70 and it is aligned with the airstream at cruise to minimise its interference drag. It can improve the maximum lift co-efficient by as much as 0.05-0.1.

V. CONCLUSION

By this experiment we are able to study about vortex generators as well as can compare the results of  $C_L$  at different angle of attack with and without vortex generators visually and computationally.

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