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Design and Analysis of Vortex Generators

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ABSTRACT

To save energy and to protect the global environment, fuel consumption reduction is primary concern of automotive development. In vehicle body development, reduction of drag is essential for improving fuel consumption and driving performance, and if an aerodynamically refined body is also aesthetically attractive, it will contribute much to increase the vehicle's appeal to potential customers. However, as the passenger car must have enough capacity to accommodate passengers and baggage in addition to minimum necessary space for its engine and other components, it is extremely difficult to realize an aerodynamically ideal body shape. The car is therefore obliged to have a body shape that is rather aerodynamically bluff, not an ideal streamline shape.

One way to overcome drag is to generate vortex flow at the rare end of the vehicle using vortex generators, reduction of drag in automobiles with vortex generators is already proved working in some previous studies, but no standard geometry is specified for the vortex generator. In this project we are going to compare the performance of different geometry's of vortex generators using Ansys 15.0 fluent workbench, all the 3d models of vortex generators are developed in Catia v5 software.

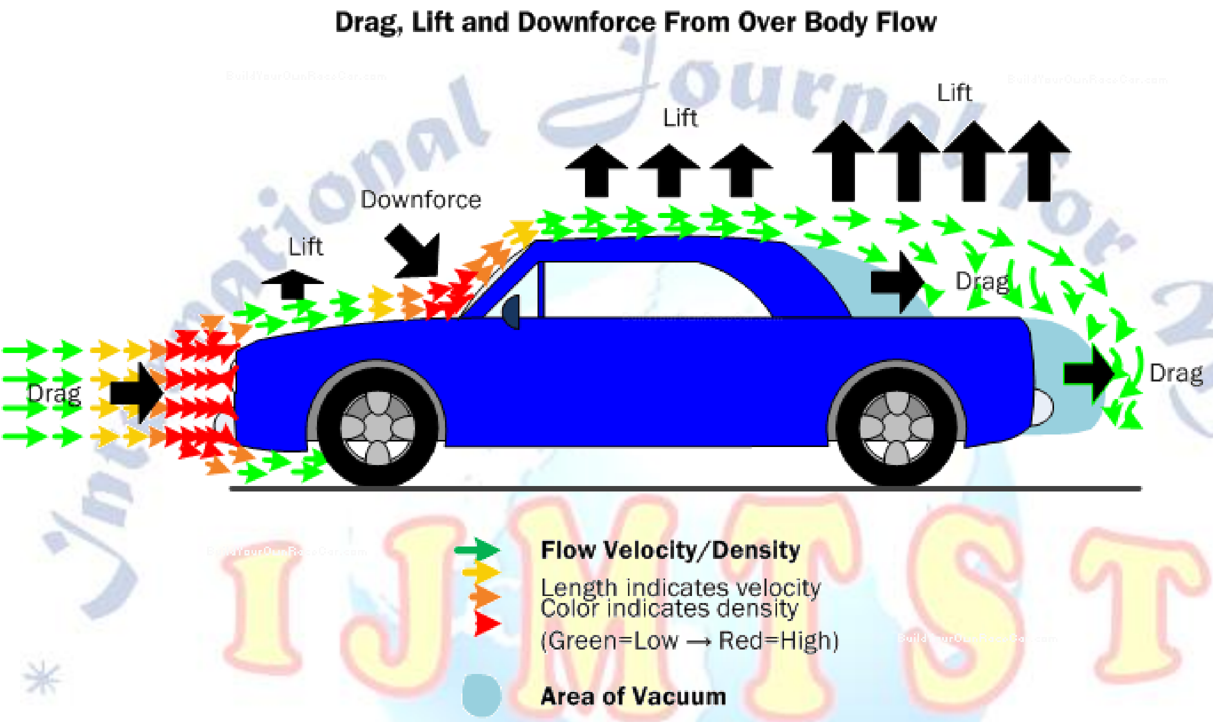
I. INTRODUCTION

A vortex generator is an aerodynamic utensil, containing of a small vane usually enclosed to a lifting surface (or airfoil, such as an aircraft wing) or a rotor blade of a wind turbine. Vertex generators may also be enclosed to some part of an aerodynamic vehicle such as an aircraft or a car. When the airfoil or the body is in movingrespective to the air, the vortex generatorproduce a vortex, by detaching some part of the slow-moving border layer in contact with the airfoil surface, retard the flow separation and aerodynamic suspend, thereby increasing the effectiveness of wings and handle the surfaces such aselevators, rudders, ailerons, and flaps.

A vortex generator is considered as submissive flow control device which increases the boundaryfluid layer motion bringing momentum from the outer division into the inner division. Furthermore, Lin et al showed the Drag reducing and the Lift increasing effect of sub boundary layer VGs. Through this uproot of energy, the velocity of the inner division is improved at the same time as the boundary layer thickness is reduced, which in turn causes the severance of the flow is delayed.

Vortex generatorsare applied on wind turbine blades with the major goal to detain or stop the separation of the flow and to reduce roughness sensitivity of the blade. They are usually placed in a span wise array on the suction side of the blade and have the benefit that they can be join as a post-production fix to blades that do not perform as anticipate. So, adding VGs is a simple solution to improving the performance of a rotor, Schubauer et al and Bragg et al.

With the help of Computational Fluid Dynamics (CFD) tools, we can design a wind turbine blade, and also to optimize the position of the vortex generators on the blade,modelling the fully-meshed Vortex generators on a full rotor computation becomes prohibitively exorbitant. The Vortex Generators area is often alike to the boundary layer thickness and many small cells are needed in the Vortex Generator geometry for having a reliable modelling of the flow. Areplacement way of modelling Vortex Generators in Computational fluid dynamics is to create a model in a way that influence of the vortex generator on the boundary layer using body forces.



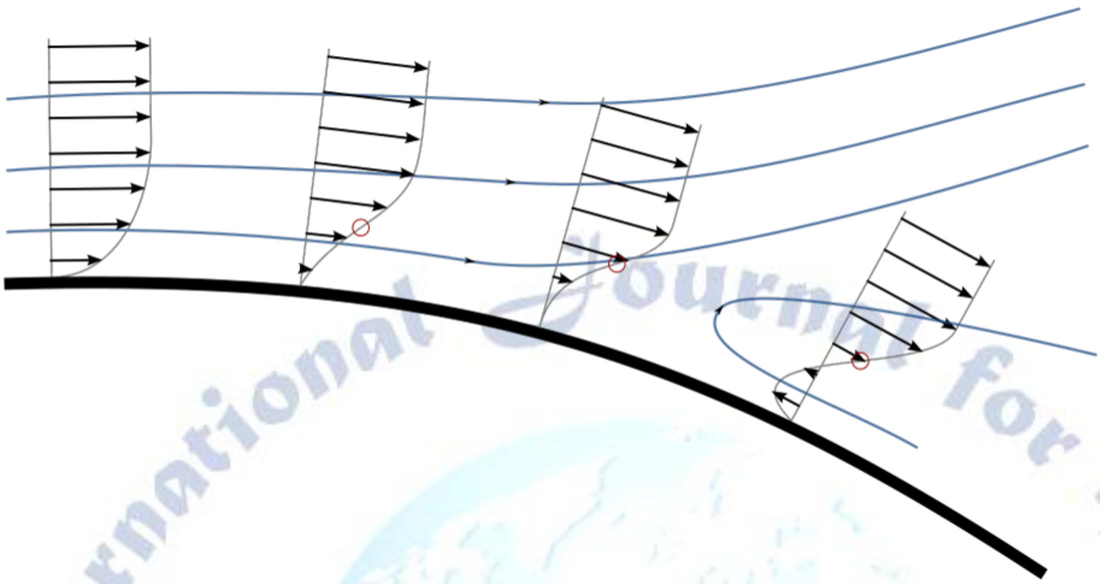
II. OPERATION OF METHOD

Flow separation can be delay by using Vortex generator. To achieve this they are generally placed on the exterior surfaces of vehicles and wind turbine blades. On both aircraft and wind turbine blades they are commonly connected very close to the leading edge of the aerofoil low-key to maintain constant airflow over the control surfaces at the tracking edge. VGs are consistently rectangular or triangular, about as tall as the local border layer, and run in span wise lines commonly near the hard part of the wing. They can be seen on the wings and vertical tails of many airlines.

Vortex generators are arranged sidelong so that they have an angle of attack related to the local airflow in consideration to create a tip vortex which ties energetic, vigorously moving outside air into the slow-moving border layer in connection with the surface. A turbulent boundary layer is less acceptable to isolate than a laminar one, and is therefore enticing to ensure capability of trailing-edge control surfaces. Vortex generators are used to trigger this transition. Other devices such as variations, leading-edge extensions, and leading edge cuffs also delay flow separation at high angles of attack by re-energizing the boundary layer

The little lumps at the top of the rear windscreen. They are called vortex generators, which were most famously used before on the Mitsubishi Lancer Evolution, and have become a niche modification for aero-obsessed petrol heads out there.

To understand what assets they bring to a car's aerodynamics, we must first look at how airflow combine with the moving body of a car. Due to friction between the solid surface and the air molecules passing over it, the air forms a fluid profile, with stationery air sitting at the point of meeting between the fluid and the surface. This profile can also be called the boundary layer. The air speed then developed to what is called free stream velocity as the distance increases from the car's body, as can be seen in the diagram below.



Unfortunately, somewhere around the end of the roof the airflow reaches a separation point and diffuses off into free air space, leaving turbulent, slow-moving air to crash about the boot area meaning very little fluid flow ever makes it smoothly down to the wing. The scrape up of the windscreen and the arc of the roofline have big implications on the characteristics of the airflow over the car and contribute to the placement of the point of separation are the factors.

Aerodynamic elements like wings and diffusers can be enhance by controlling the distance at which the separation flow occurs, although this separation point is certain. This can be attained using - you guessed it - vortex generators.

Model without vertex generator at speed 1

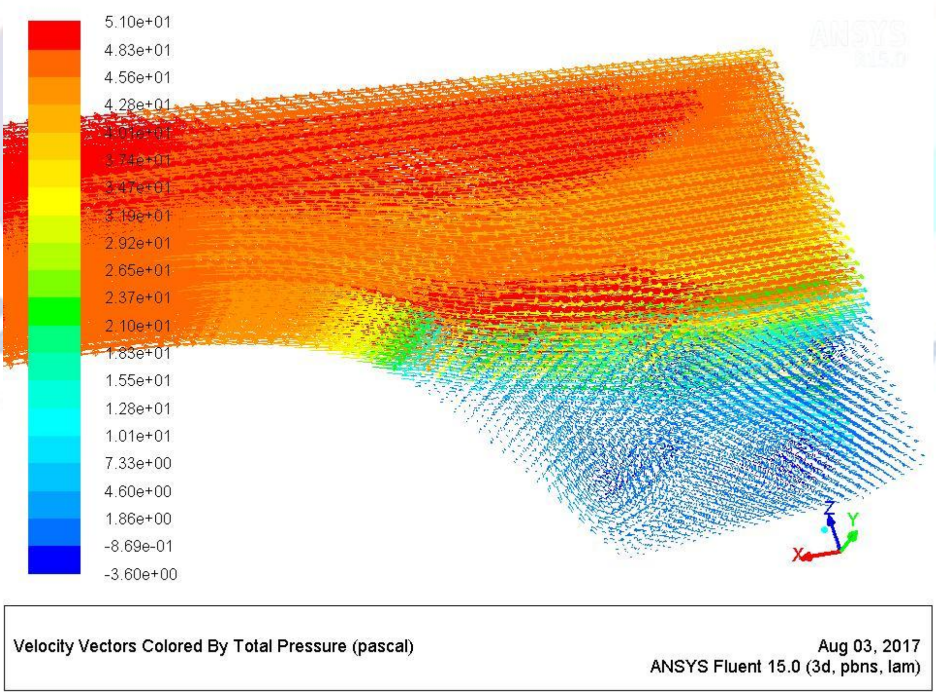


Fig: Picture representing total pressure

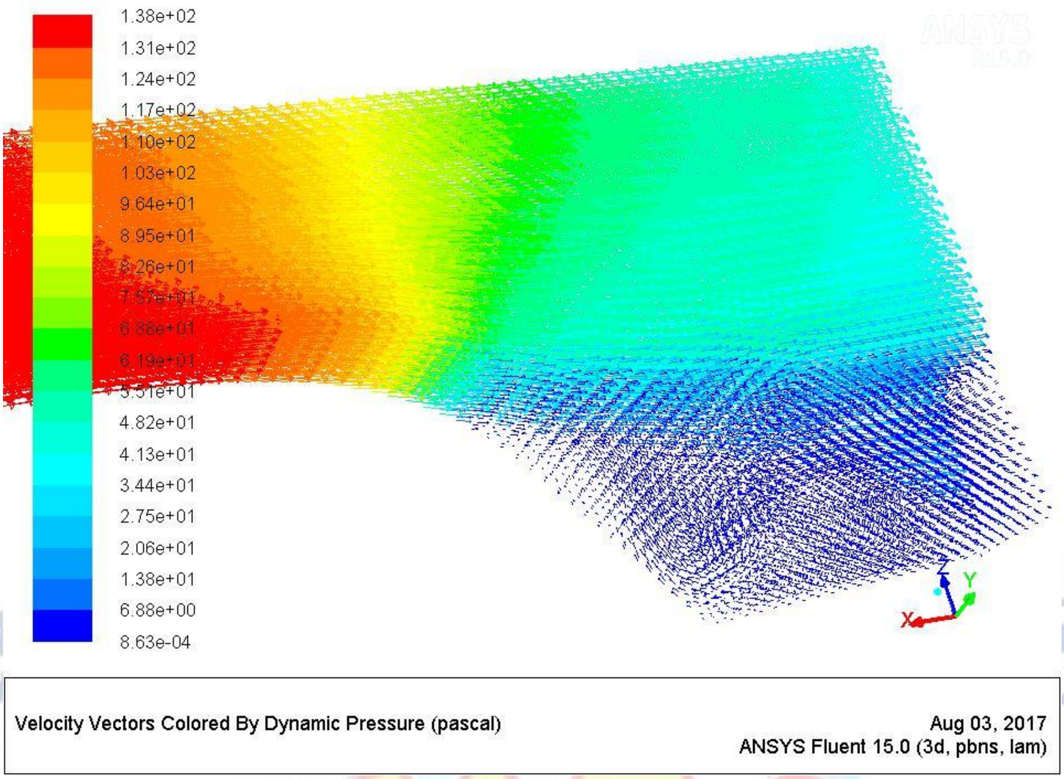


Fig: picture representing dynamic pressure

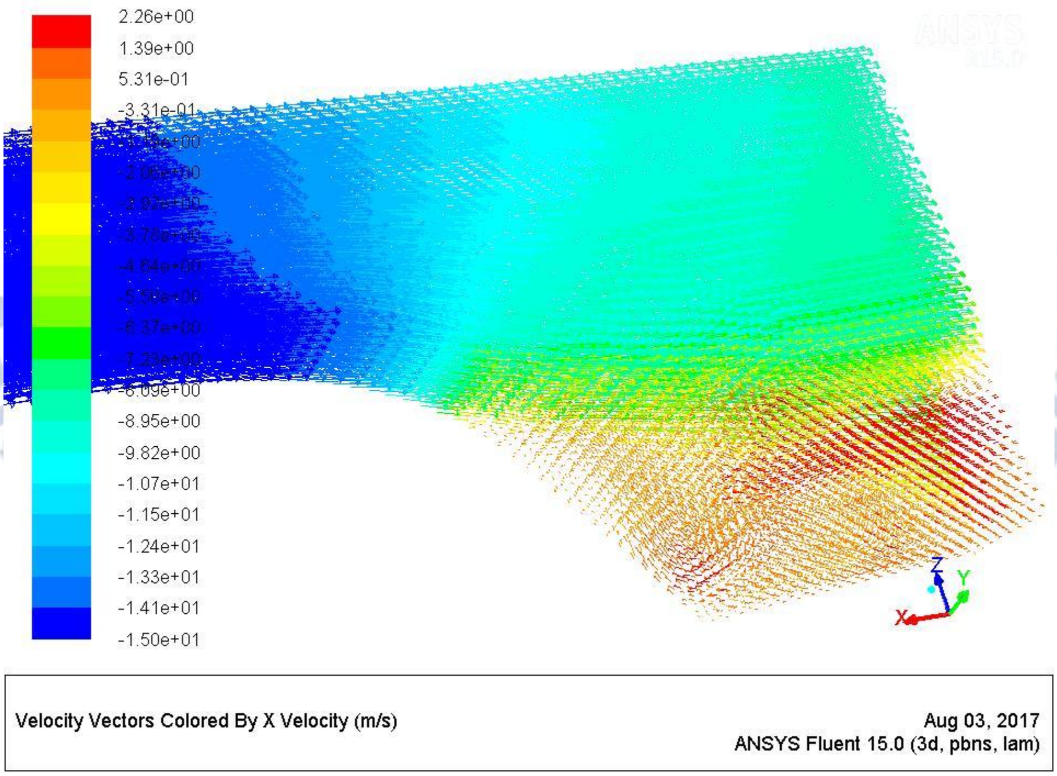


Fig: Picture representing x velocity

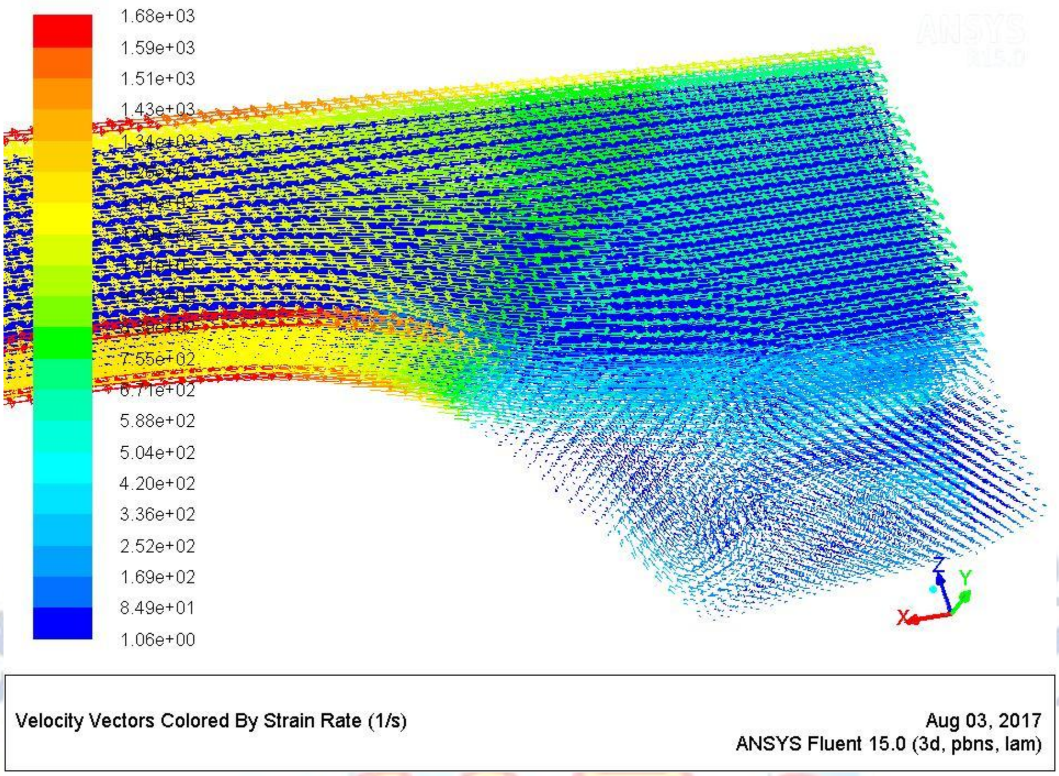


Fig: Picture representing strain

REPORT

1Table representing different models at wind speed 20.2778mps

Model At wind speed 14.7222mps	Total pressure		Dynamic pressure		X-velocity		Strain rate	
	min	max	min	max	min	max	min	max
model without VG	-3.60E+00	4.83E+01	8.63E-04	1.31E+02	-1.50E+01	2.26E+00	1.06E+00	1.59E+03
model 1	-1.47E+02	2.09E+02	7.43E-03	3.89E+02	-2.51E+01	6.30E+00	1.24E-01	1.17E+05
model 2	-2.36E+02	1.31E+03	1.52E-02	1.38E+03	-2.50E+01	1.15E+01	2.46E-01	8.81E+04
model 3	-2.24E+02	2.36E+02	7.85E-03	4.86E+02	-2.77E+01	8.30E+00	2.23E-01	1.44E+05

Table representing different models at wind speed 20.2778mps

At wind speed 20.2778mps	Total pressure		Dynamic pressure		X-velocity		Strain rate	
	min	max	min	max	min	max	min	max
model 1	-1.18E+02	5.33E+01	1.42E-02	2.61E+02	-2.07E+01	9.09E+00	1.42E+00	2.31E+03
model 2	-3.45E+02	3.70E+02	9.45E-03	7.28E+02	-3.41E+01	1.13E+01	1.33E-01	1.87E+05
model 3.3	-5.24E+02	2.78E+02	1.24E-02	7.57E+02	-3.51E+01	1.26E+01	3.70E-01	1.36E+05
model 4	-4.37E+02	4.54E+02	3.65E-02	9.10E+02	-3.80E+01	1.14E+01	2.89E-01	1.99E+05

Table representing different models at wind speed 20.2778mps

at wind speed 20.2778mps	Total pressure		Dynamic pressure		X-velocity		Strain rate	
	min	max	min	max	min	max	min	max
model 3.1	-4.41E+02	3.87E+02	2.29E-02	8.16E+02	-3.63E+01	1.35E+01	1.95E-01	1.28E+05
model 3.2	-5.58E+02	4.97E+02	1.72E-03	1.06E+03	-4.12E+01	8.76E+00	1.75E-01	1.18E+05
model 3.3	-5.24E+02	2.78E+02	1.24E-02	7.57E+02	-3.51E+01	1.26E+01	3.70E-01	1.36E+05
model 3.4	-5.20E+02	2.36E+02	2.09E-02	7.31E+02	-3.51E+01	1.03E+01	7.95E-01	1.30E+05
model 3.5	-4.24E+02	2.40E+02	1.27E-02	7.98E+02	-3.55E+01	6.42E+00	8.44E-01	1.74E+05

Table showing drag force in x-direction for various vertex

Drag force in x direction in newton's	speed 1	speed 2	speed 3
without vortex	0.561684	2.610895	1.888333
vortex model 1	0.495511	2.114732	3.781421
vortex model 2	0.272552	1.008626	1.025085
vortex model 3	0.427704	1.286723	0.409939

Table showing drag force in x-direction for various vertex models

Drag force in x direction in newton's	speed 1	speed 2	speed 3
vortex model 2.1	0.272552	1.008626	1.025085
vortex model 2.2	0.851158	1.708981	2.478753
vortex model 2.3	0.924419	1.625015	2.612897
vortex model 2.4	0.802298	1.563699	2.473084
vortex model 2.5	0.796145	1.52705	2.732052

III. CONCLUSIONS

In this thesis CFD analysis is performed on a car cut section with different vortex, vertex generators are developed with varying the angle of nose section, From the results the following observations are made

1. Vertex generator with maximum height shows maximum performance.
2. Moderate conic sections are preferable while designing a vortex generator.
3. In this study lowest drag force is recorded in vortex generator model 2 with max height.
4. With decrease in height of vortex generator the drag increases.
5. An average of 1.5 N/mm2 is observed between model without vortex and model with vortex model 2.

FUTURE SCOPE

This project can be carried forward by doing some wind tunnel experimentation to study the aerodynamic behavior of vortex by varying geometry, theoretical work could be done for the same.

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