THE COMPUTATIONAL ANALYSIS OF SEDAN CAR WITH VORTEX GENERATOR

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ABSTRACT

The main cause of pressure drag is the separation of air flow at the top surface of car. So this invention aims to delay flow separation by keeping Vortex Generators. The experimental investigations were performed on BLWT, while computational analysis was carried out using Standard computational software. Pressure measurements were made for the model when the wind was flowing parallel to the length of the car, with and without Vortex generators. As per the computational and experimental analysis it's observed and proved that, the drag co-efficient of car model was reduced by keeping Vortex Generators.

Keywords: Flow Separation, Sedan Car, Vortex Generator, Wind Tunnel.

I. INTRODUCTION

Automobile industry aims at producing car's which will have reduced drag, so as to improve performance and fuel consumption of the car. The cars adopt airfoil shape in order to produce high speed. This airfoil shape cannot be completely achieved due to the various aspects of car such as passenger seats, engine spaces, rear deck etc. In commercial cars, aesthetic appearance and comfort also plays a very important role to earn market. Thus the cars body will be made entirely with aerodynamic aspects; it tends to become aerodynamically bluffed. Due to this, it faces flow separation at the rear end. The car design is the key aspect for the success of the automobile industry producing cars.

II. VEHICLE AERODYNAMICS

Vehicle aerodynamics is the study of the aerodynamics of road vehicles. The main concerns of vehicle aerodynamics are reducing drag , reducing wind noise, minimizing noise emission, and preventing undesired lift forces and other causes of aerodynamic instability at high speeds. For instance the flow separation increases the drag in the car, these vehicle aerodynamics are necessary to identify the techniques to delay the flow separation. An aerodynamic automobile will integrate the wheel arcs and lights into the overall shape to reduce drag. It will have a flat and smooth floor to support the Venturi effect and produce desirable downwards aerodynamic forces**.**

The air that rams into the engine bay, is used for cooling, combustion, and for passengers, then reaccelerated by a nozzle and then ejected under the floor. For mid and rear engines air is decelerated and pressurized in a diffuser, loses some pressure as it passes the engine bay, and fills the slipstream. The cars needs a seal between the low pressure region around the wheels and the high pressure around the gearbox. They all have a closed engine bay floor. The suspension is either streamlined or retracted. Door handles, the antenna, and roof rails can have a

streamlined shape. Streamline are uniform curves similar to the pictorial representation of air flow below.The side mirror can only have a round fairing as a nose. Air flow through the wheel-bays is said to increase drag, though race cars need it for brake cooling and a lot of cars emit the air from the radiator into the wheel bay.Vehicle aerodynamics differs from aircraft aerodynamics in several ways. First, the characteristic shape of a road vehicle is much less streamlined compared to an aircraft. Second, the vehicle operates very close to the ground, rather than in free air. Third, the operating speeds are lower and aerodynamic drag varies as the square of speed. Fourth, a ground vehicle has fewer degrees of freedom than an aircraft, and its motion is less affected by aerodynamic forces. Fifth, passenger and commercial ground vehicles have very specific design constraints such as their intended purpose, high safety standards.The factors on which Vehicle Aerodynamic depends are Aerodynamic Forces, Laminar Separation, Tripping of Boundary Layer, Pressure Distribution, Wake, Tires, Glass and Trim, General Improvements and Unconventional Features

III. FLOW SEPARATION

Flow separation occurs when the boundary layer travels far enough against an adverse pressure gradient that the speed of the boundary layer relative to the object falls almost to zero. The fluid flow becomes detached from the surface of the object, and instead takes the forms of eddies and vortices.

Fig 1: Flow separation over an sedan car

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. Fig 1 schematically shows the flow around a sedan car. Flow separation increases drag and hence the coefficient of drag vary in accordance to the design of the car. It occurs when the boundary layer travels against an adverse pressure gradient that the speed of the boundary layer to the object is almost zero. The fluid flow tends to detach from the surface of the object, and takes the forms of eddies and vortices. The scope of this paper is to improve the performance and reduce fuel consumption of a sedan type car .This increase in performance can be achieved by using an aerodynamic tool called vortex generator to the roof of the car and the constraints faced are Shape of the vortex generator and Size of the vortex generator.To improve the performance and efficiency of the car, we have done the following changes in the car.

1. Placing nine number ofVGs at the roof of the car.
2. Comparing the performance by using delta wing shaped and right angled shape vortex generator.
3. Considering the height of the vortex generator as 10mm.

IV. VORTEX GENERATOR

Vortex generator (VG) is an aerodynamic surface, consisting of a small vane or bump that creates a vortex. Vortex generators delay flow separation and aerodynamic stalling, thereby improving the effectiveness of wings and control surfaces. We have chosen vortex generator as our aerodynamic device to be implemented in the sedan car to enhance the performance of the car. VGs were developed for the aircraft sector, this technology has made it's way into car design. The main function of this device is to delay air flow separation. Air flow separation is when the airflow of an object detaches from the surface and creates eddies and vortexes. So vortex generator over the rear of the roof, effectively helps to reduce drag.

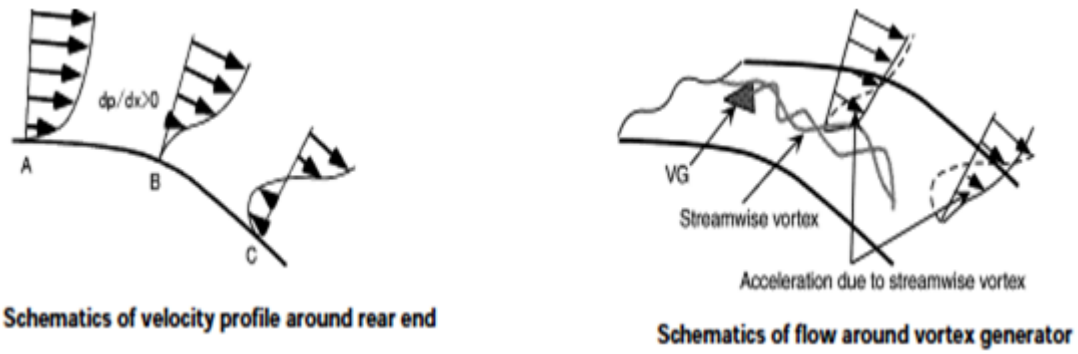


Fig 2.VG at the rear end of the car

The fig shows a flow velocity profile on the vehicle's centerline plane near the roof end. Since the vehicle height in this section becomes progressively lower as the flow moves downstream, an expanded airflow is formed there. This causes the downstream pressure to rise, which in turn creates reverse force acting against the main flow and generates reverse flow at downstream Point C.No reverse flow occurs at Point A located further upstream of Point C because the momentum of the boundary layer is prevailing over the pressure gradient (dp/dx). Between Points A and C, there is separation Point B, where the pressure gradient and the momentum of the boundary layer are balanced. Here the airflow quickly loses momentum as it moves downstream due to the viscosity of air. The purpose of adding VGs is to supply the momentum from higher region to lower region. This allows the separation point to shift further downstream. So it enables the expanded airflow to persist proportionately longer. It reduces drag by increasing g the back pressure. It provides dual advantage in drag reduction: one is to narrow the separation region in which low pressure constitutes the cause of drag another is to raise the pressure of the flow separation region. As to the location of VGs, a point immediately upstream of the flow separation point was assumed to be optimum, and a point 100 mm in front of the roof end was selected.

V. RESULT AND ANALYSIS

GAMBIT is a general purpose preprocessor for CFD analysis.**G**eometry **A**nd **M**esh **B**uilding **I**ntelligent **T**oolkit is a meshing software package which is used to generate the model of car and mesh it with the domain.Fluent software contains the broad physical modeling capabilities needed to model flow. It is an integral part of design and optimization phases of the product. It provides accurate CFD results, flexible moving and deforming meshes and superior parallel scalability. The interactive solver setup, solution and post-processing capabilities of Fluent make it easy to handle a calculation, examine results with integrated post-processing, change any setting, and then continue the calculation within a single application.

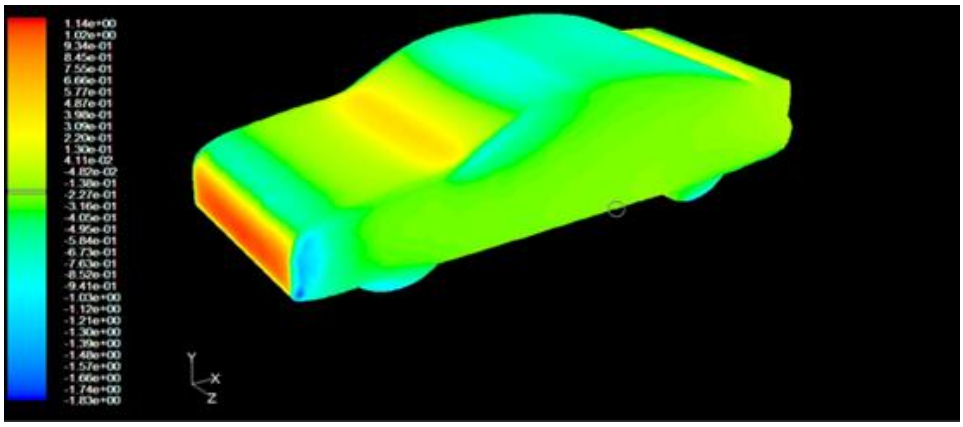


Fig .3: Pressure Coefficient Generated Without Vortex Generator

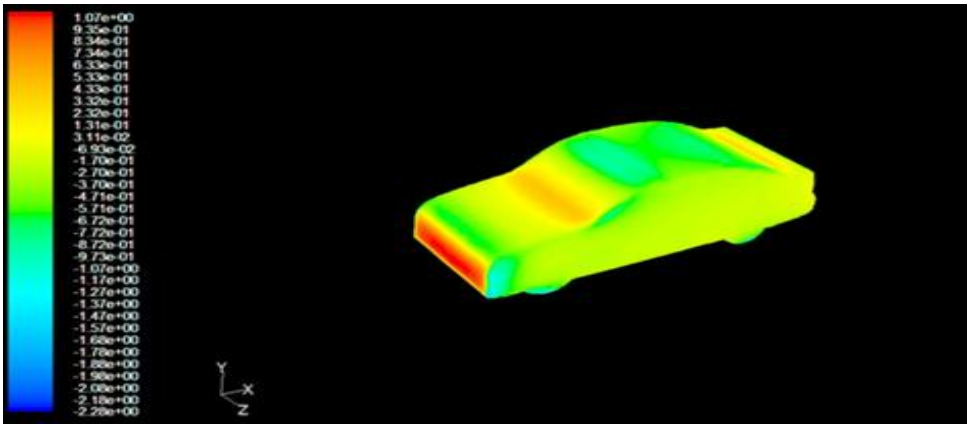


Fig .4: Pressure Coefficient Generated with Vortex Generator

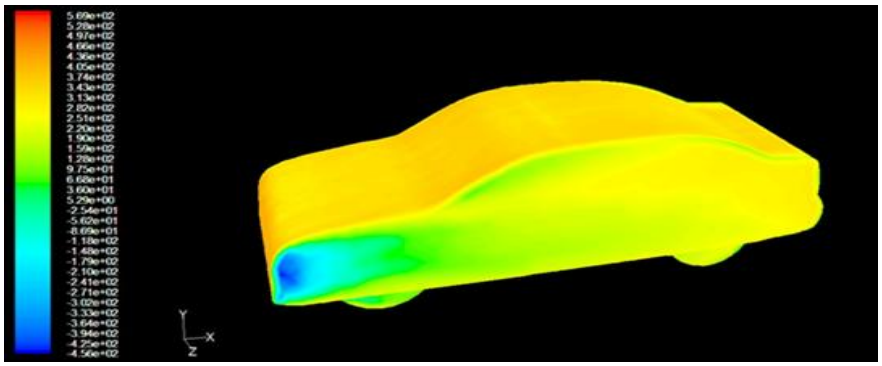


Fig .5: Total Pressure Generated without Vortex Generator

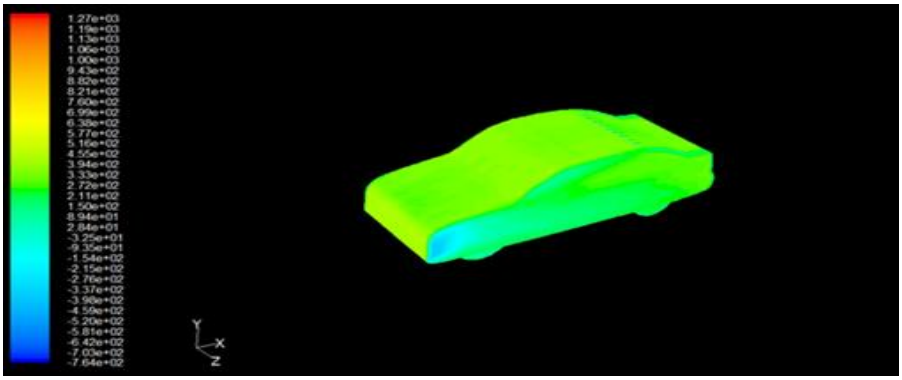


Fig 6: Total Pressure Generated with Vortex Generator

Zone name	Pressure force	Viscous force	Total force	Pressure coefficient	Viscous coefficient	Total coefficient
Car	4.08E+08	8308778.2	4.16E+08	1.05E+00	21952.466	1069634
Car with VG	3.93E+08	8174012.2	4.02E+08	1.03E+00	21352.469	1049013.7

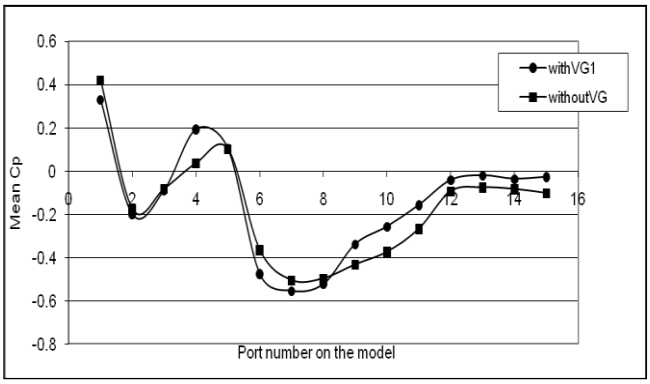
Table 1 :Comparison of Forces with and without Vortex Generator

The enhanced performance of the vortex generator was determined and the comparison was made between right angle shape and delta wing shape vortex generators. The addition of the vortex generators at the rear end of the car gave an average reduction of drag by -0.006. Vortex generator is a viable method of performance enhancement in cars. Vortex generators can be added to other standard enhancement techniques by varying the size, shape, thickness and height. The results in reducing the drag, shifting the flow separation point and narrow the flow separation

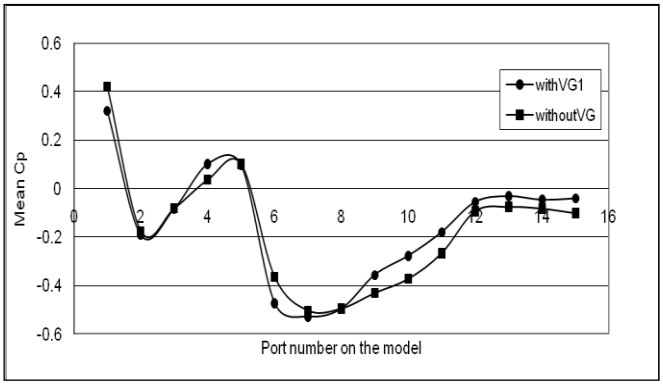
region. This project focused on the enhancement of the performance of cars using different shapes of vortex generators and the comparison results that the right angle shape vortex generator gave the better performance.

5.1 Comparison of Model With Vg

C_p curve for 19.01m/s for model:



Graph.1: delta shaped VG



Graph.1: right angle VG

The co-efficient of drag for the model with delta shaped VG for 19.01m/s is estimated as,

C_d with reference to maximum height from ground = 0.086614

C_d with reference to individual port height = 0.326612

C_d with reference to maximum height excluding ground clearance = 0.102774

The co-efficient of drag for the model with right angle shaped VG for 19.01m/s is estimated as,

C_d with reference to maximum height from ground = 0.090216

C_d with reference to individual port height = 0.332263

C_d with reference to maximum height excluding ground clearance = 0.11002

VI. CONCLUSION

It is concluded that both the vortex generators i.e. delta shaped and right angle shaped have the significance effect in reducing the drag force and also it is concluded that both the positions i.e. after front wind shield and top roof end has considered as the significant place in delaying the flow separation region. But there is an optimum position in the car model that should have to be found out and also the optimum shaped Vortex Generator in which the drag force is said to be least. Considering all the results and graph, the optimum shaped vortex generator and position is,Flow gets reattached in the areas of back wind shield, boot, and rear end by keeping Delta Shaped Vortex Generator at beginning of Front wind shield. But in the model those above said regions show there is no reattachment of flows that contributes more drag in the car.As a result of the verifications, it is confirmed that VG create stream wise vortices, the vortices mix higher and lower layers of boundary layer and the mixture causes the

flow separation point to shift downstream, consequently separation region is narrowed. From this, we could predict that VGs cause the pressure of the vehicle's entire rear surface to increase and thereby decreasing the drag.

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