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ANALYSIS OF CAR BODY AERODYNAMICS TO REDUCE DRAG COEFFICIENT USING CFD TOOL

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***Abstract -** Aerodynamics concerns with the study of the ait motion when the air interacts with the moving objects. Aerodynamics in the automotive field refers to the study of motion of air when it interacts with the road vehicles. The study of aerodynamics in the field of automotive is important to improve the performance of the vehicle by controlling parameters such as drag, wind noise, and undesired lift forces. Study of aerodynamics is also very important in certain cases where it is also useful to generate down force. Aerodynamic drag is one of the main obstacles to accelerate a solid body when it moves in the air. In this paper, we have performed Computational Fluid Dynamics analysis on two different geometries using STAR CCM+ software with the main aim being reduction in Coefficient of Drag. First, we analysed the car without vortex generators using STAR CCM+. Then we added seven vortex generators to the geometry of the same care and ran the analysis again. We noted the velocity, pressure and Vortex generation around the car body at a certain velocity. In conclusion, we compared the results from both the analysis.*

***Key Words*:** Aerodynamic drag, Coefficient of Drag, CFD …

1. INTRODUCTION

The aerodynamics of the car is perhaps the most important aspect to take into consideration while designing a car. Better aerodynamics leads to increased stability and speed of a vehicle and makes it more fuel efficient and safe. The aerodynamics of vehicle is divided into three categories.

1. Flow around the body
2. Flow through the body
3. Flow within the machinery

We have analysed the flow around the body. And the results were then plotted on chart and the effects of vortex generator in the drag reduction was observed. Furthermore, we have also shown meshing independency.

1.1 Drag Coefficient

A drag force is the resistance force caused by the motion of a body through a fluid, such as water or air. Around half of the energy produced by burning of the fuel is spent on overcoming this force. Drag force acts opposite to the direction of the oncoming flow velocity. This is the relative velocity between the body and the fluid. Having a low Drag coefficient means that a vehicle can move easily through the air with minimum resistance. The drag force *D* exerted on a body traveling through a fluid is given by following equation.

$$D = \frac{1}{2} C \rho A v^2$$

Where:

D = Drag Force

C = the drag coefficient, which can vary with the speed of the body.

P = the density of the fluid through which the body is moving

v = the speed of the body relative to the fluid

A = the projected cross-sectional area of the body perpendicular to the flow direction

1.2 Vortex Generator

To improve the performance of a car, certain factors are taken into consideration when developing an automobile. These factors include aerodynamic properties of a car, fuel efficiency and aesthetic consideration. In recent time, it has been main goal of automobile company to reduce the drag of car. There have been many researches on this topic. Vortex generators are one of many ways to reduce the drag of the car body aerodynamics.

2. COMPUTATIONAL FLUID DYNAMICS

CFD is the branch of fluid mechanics which deals with solving mathematical equations to predict the direction of the fluid flow. It is widely used because of high number of iterations and less time consuming. Advantages of CFD includes flexibility to change design parameters, and less cost. We have also used CFD tool in STAR CCM+ software to analyse the pressure contour, velocity contour and the vortex contour of an automobile body.

3. ANALYSIS

3.1 Model 1 –without vortex generators.

First, the geometry of a car is created with the use of sold work without vortex generators.

a) Geometry

Fig. 1 Geometry without Vortex Generators

b) Boundary Conditions

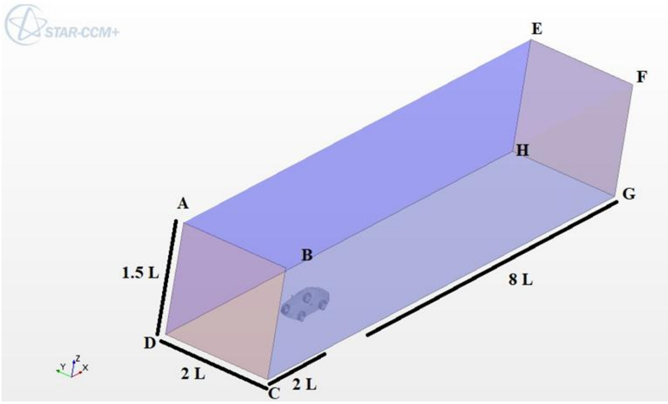

Fig. 2 Boundary Conditions

Where;

ABCD = Velocity Inlet (U_i)

EFGH = Pressure Outlet

AEHD, BFGC, AEFB – Far Field

CDHG – Tangential Velocity (U_t)

$U_i = U_t$

L = 4726 mm.

c) Meshing

Fig. 3 Meshing Without Vortex Generator

Mesh Type – Polyhedral

Mesh Count - 641206

d) CFD Analysis Results

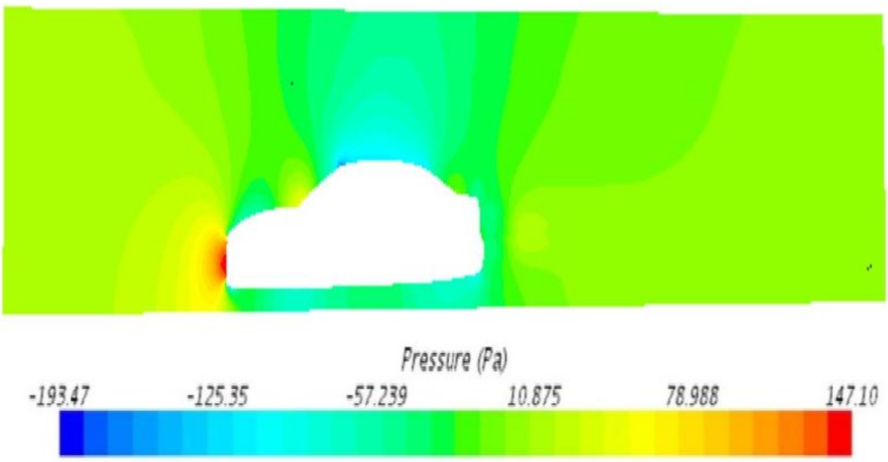

Fig. 4 Pressure contour Without Vortex Generators

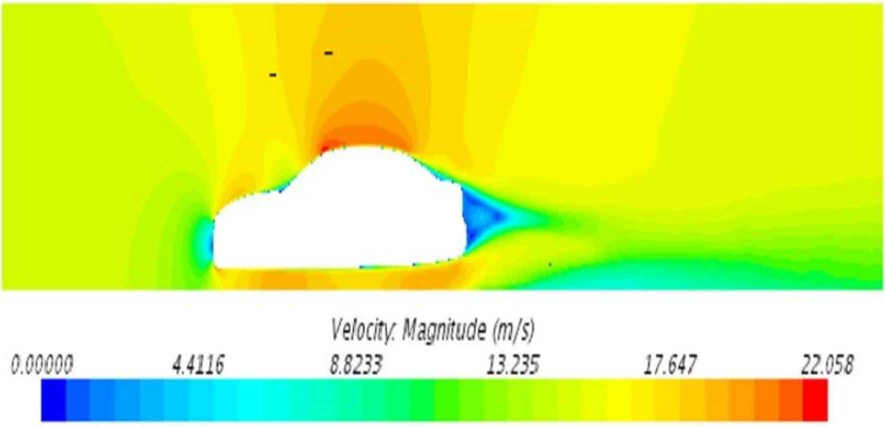

Fig. 5 Velocity Contour without Vortex Generators

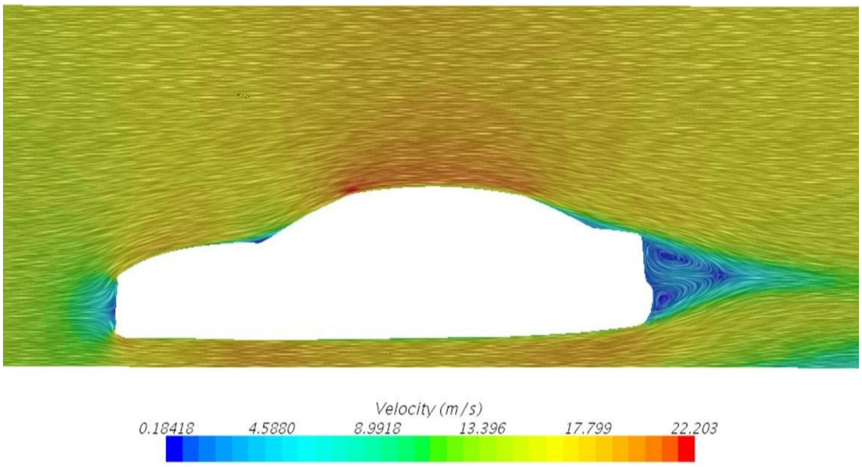

Fig. 6 Vortex Contour without Vortex Generators

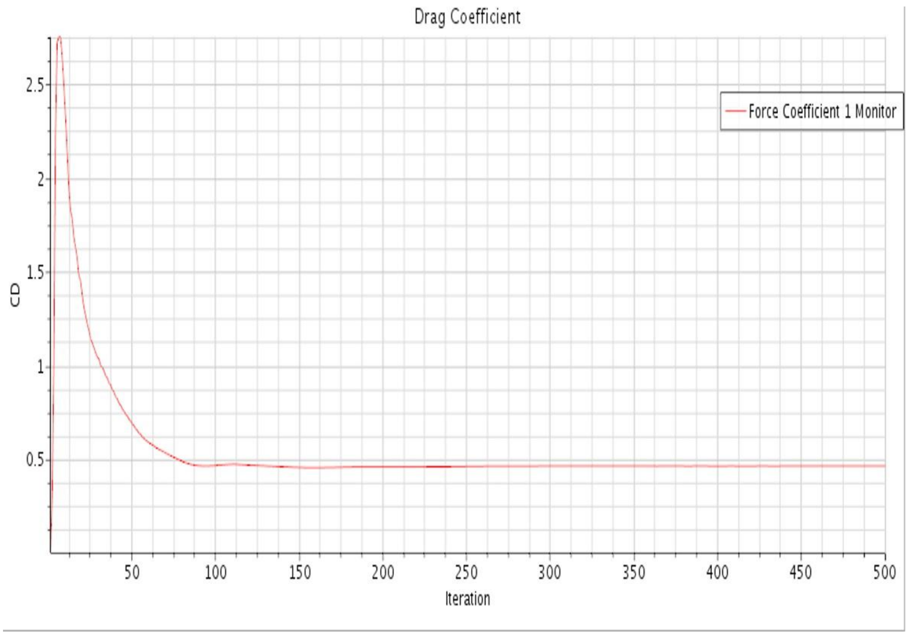

Chart 1 Drag Coefficient without Vortex Generators

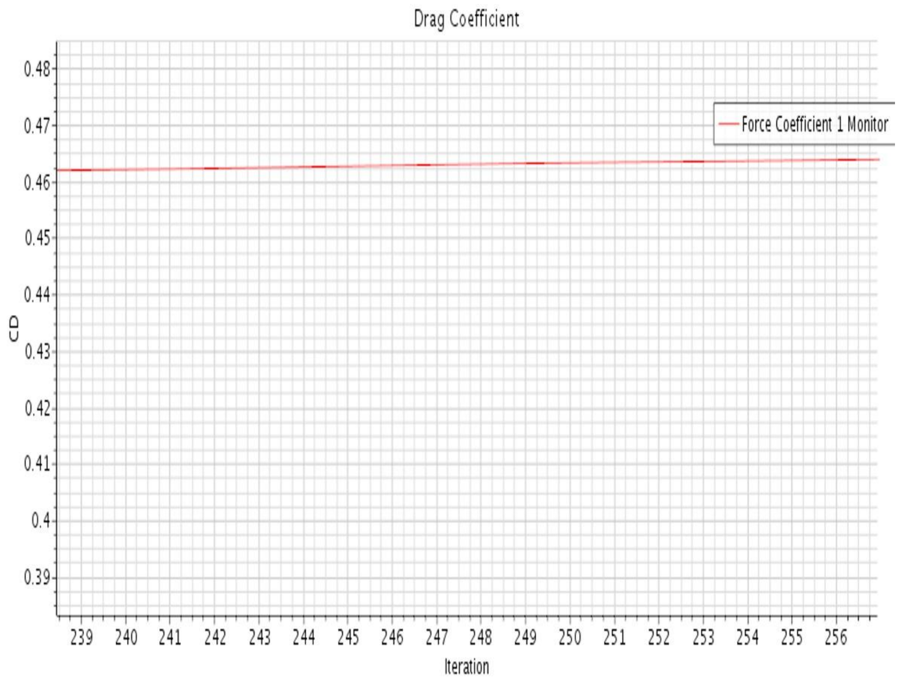

Chart 2 Drag Coefficient without Vortex Generators

Table 1 Drag Coefficient without vortex generator

Velocity (mph)	Drag coefficient without vortex generators
33.554	0.463155
71.582	0.46254
129.742	0.46068

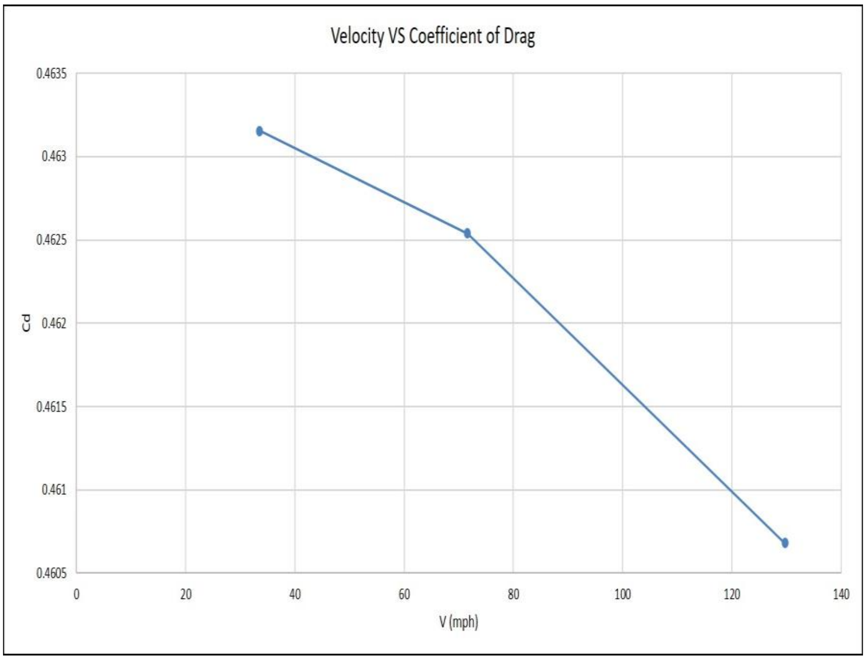

Chart 3 Velocity vs Coefficient of Drag

3.2 Model 2 – With Vortex generators

In the second analysis, vortex generators are attached at the roof of the car. Total of 7 vortex generators were attached each of length 80 mm, width 20 mm, height 90 mm, and radius 60 mm. The vortex generators were placed 100 mm from the rear end of the top.

a) Geometry

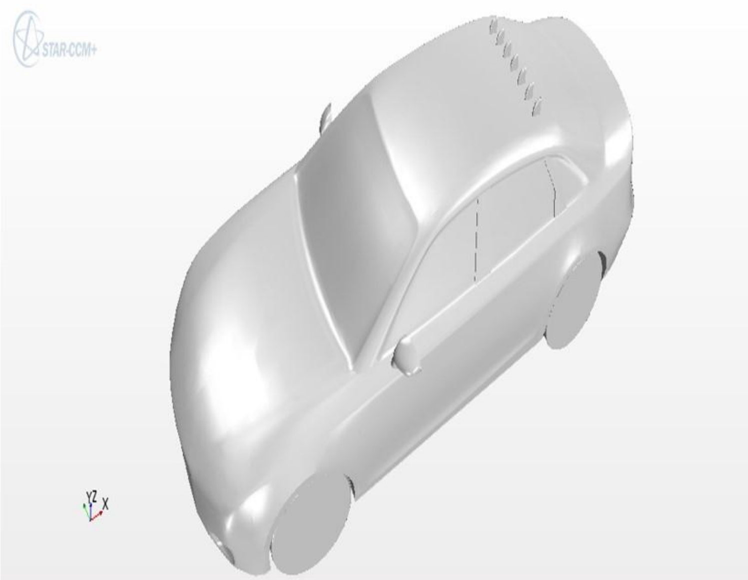

Fig. 7 Geometry with Vortex Generators

Boundary conditions are the same as without vortex generators

b) Meshing

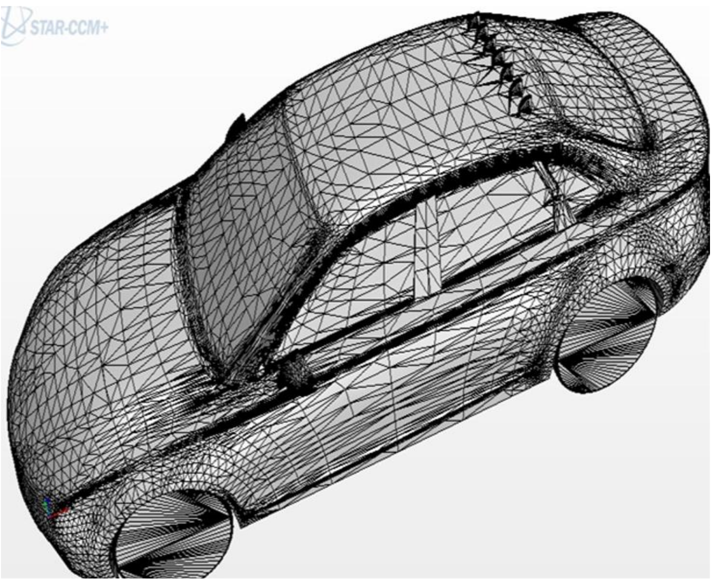

Fig. 8 Meshing with Vortex Generators

Mesh Type – Polyhedral

Mesh Count - 796578

c) CFD Analysis Results

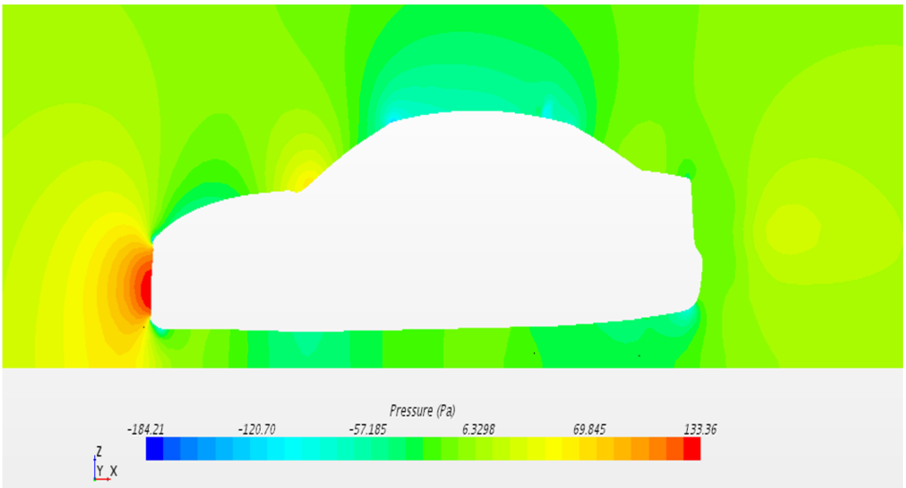

Fig. 9 Pressure contour with Vortex Generators

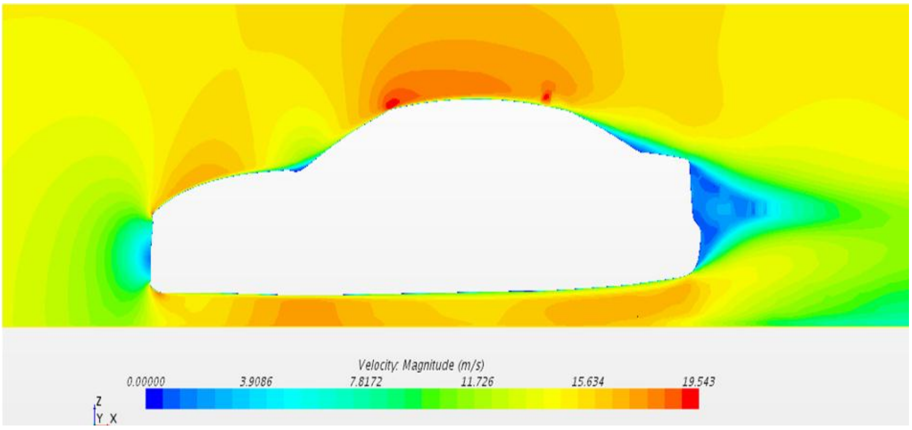

Fig. 10 Velocity Contour with Vortex Generators

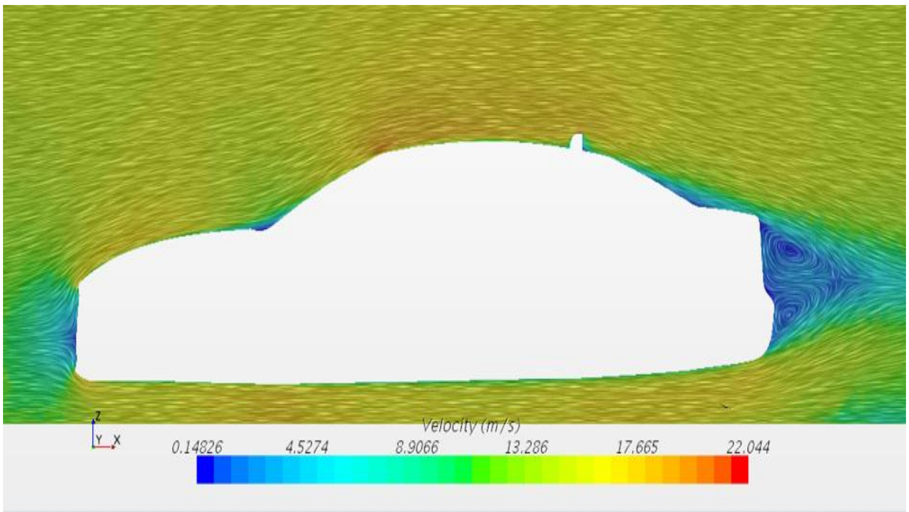

Fig. 11 Vortex contour with Vortex Generators

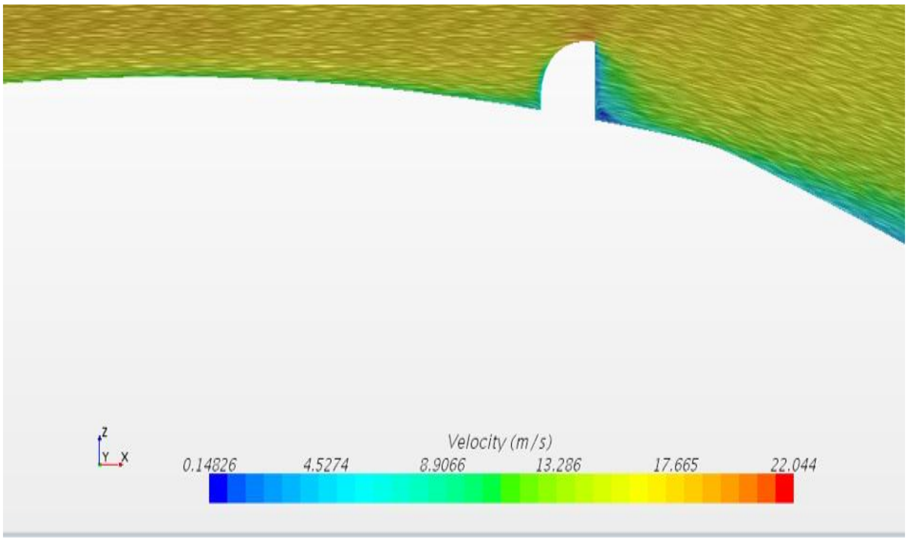

Fig. 12 Vortex contour with Vortex Generators

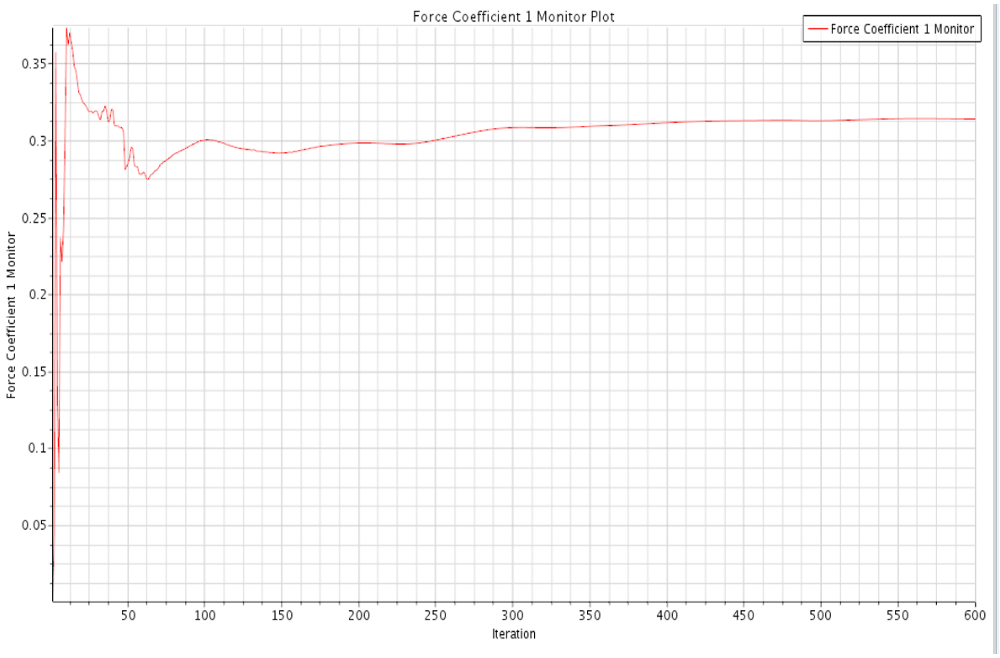

Chart 4 Drag Coefficient with Vortex Generators

Table 2 Drag Coefficient without vortex generator

Velocity (mph)	Drag coefficient with vortex generators
33.554	0.3127347
71.582	0.3125
129.742	0.311606

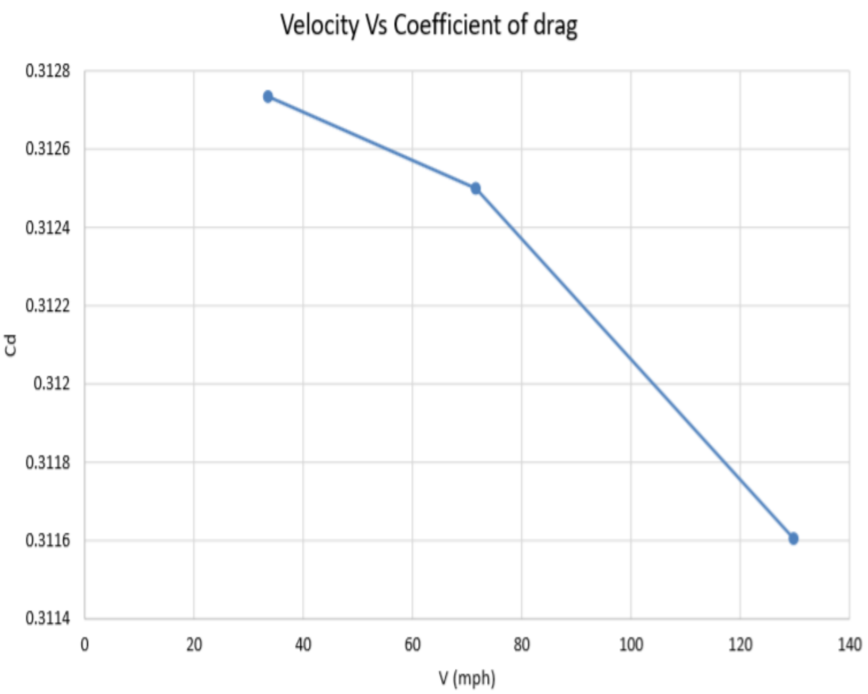

Chart 5 Velocity vs Coefficient of Drag

4. MESHING INDEPENDENCY

4.1 Base size 0.5

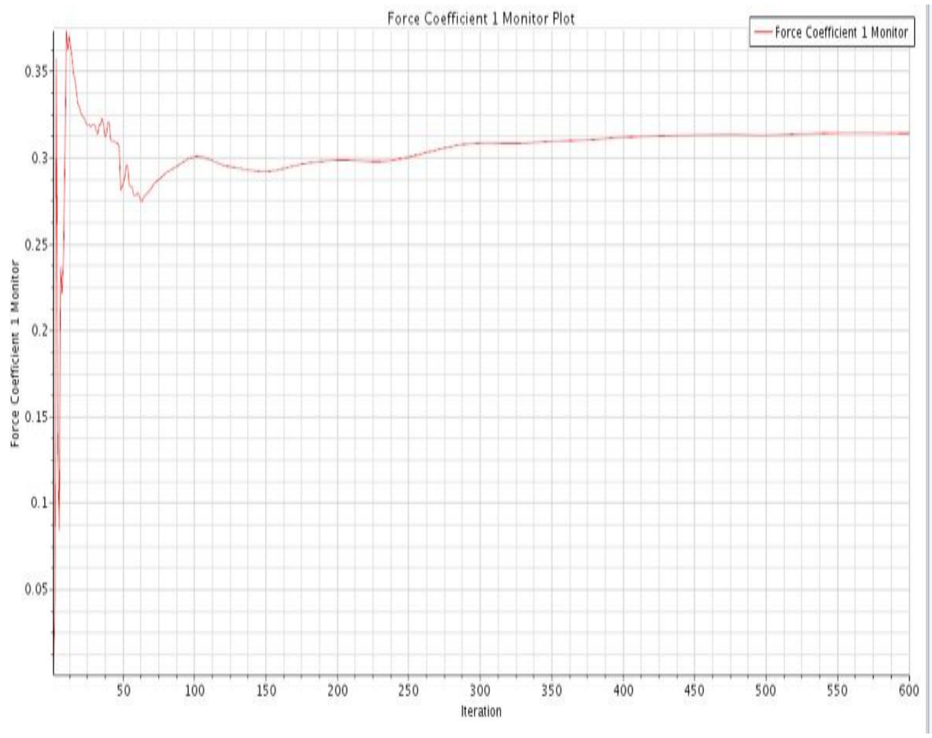

Chart 6 Drag Coefficient@Base size 0.5

4.2 Basic Size = 2

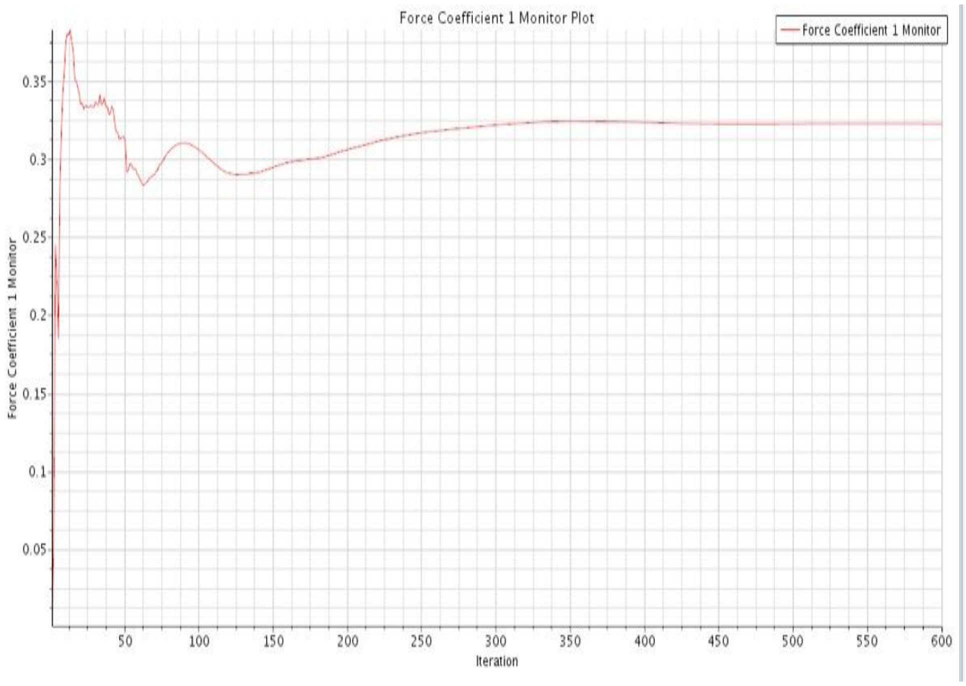

Chart 7 Drag Coefficient with@Base size 2

4.3 Basic Size = 3

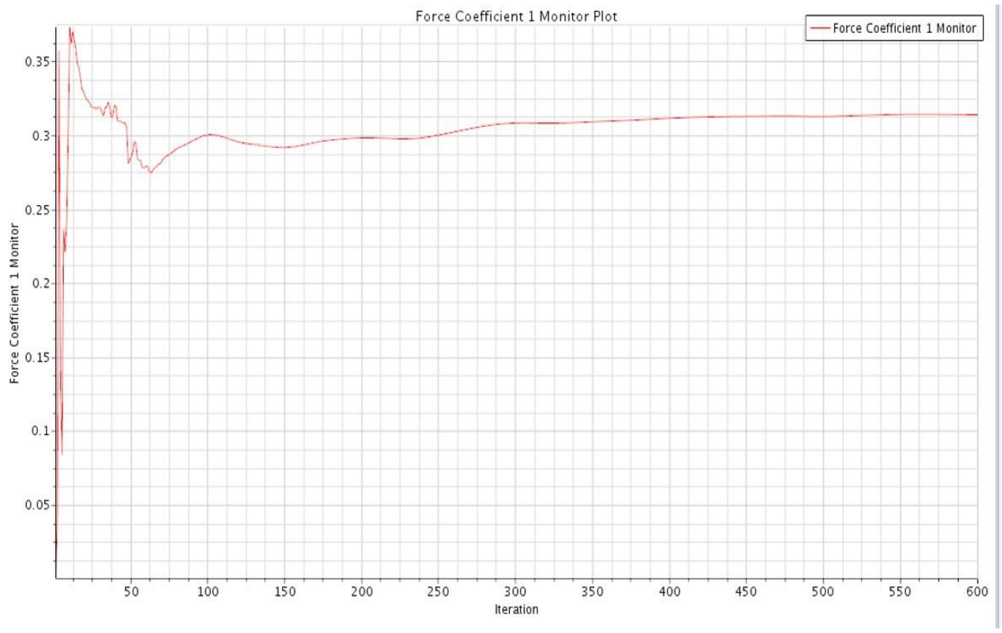

Chart 8 Drag Coefficient with@Base size 3

Table 3 Meshing Independency

Base Size	No. of Cells	Cd
0.5	1132621	0.306031
2	576625	0.32266
3	439322	0.3261416

5. COMPARISON OF DRAG COEFFICIENT

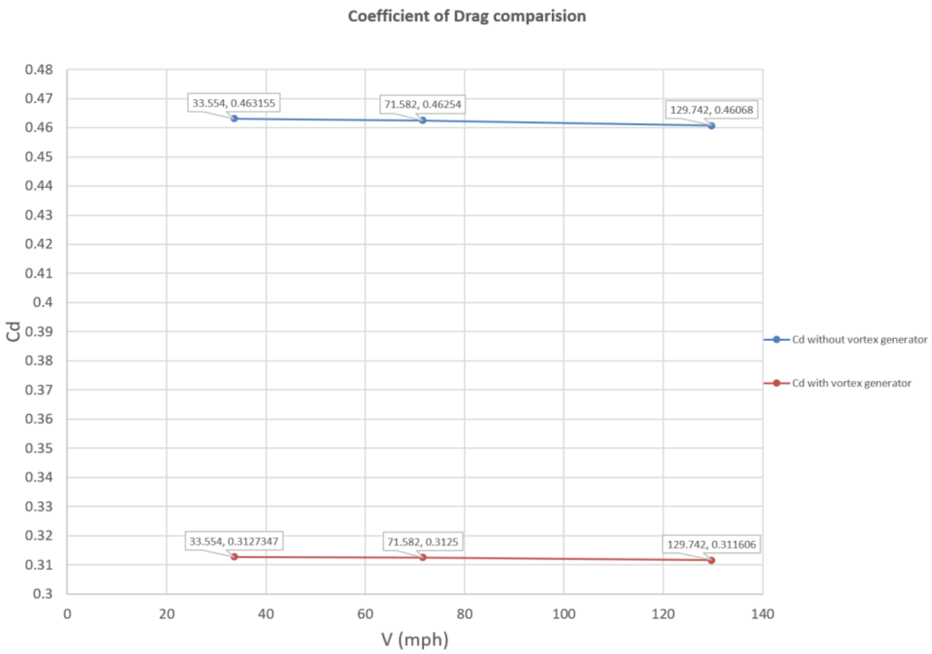

Chart 9 Comparison of Drag Coefficient

6. CONCLUSION

From analysis it is clear that the flow of air tends to separate without implementation of vortex generators at the back end. Implementation of vortex generators at the back end leads to better control of flow separation and drag reduction thereby improving the overall performance of an automobile. Hence, it can be concluded that aerodynamic stability and fuel economy can be improved by implementation of vortex generators.

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