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Modeling and Analysis of Different Vortex Generators for Sedan Type and Hatch Back Type Cars

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Abstract: Modeling and analysis of vortex generator by using Computational Fluid Dynamic (CFD) on four wheeler vehicle (FWV) model was carried out on this project. One of the main causes of aerodynamic drag for vehicle is the separation of flow near the vehicle's rear end.

To control the flow separation, Different shapes of vortex generator are test for application to the roof end of vehicle. A vortex generator (VG) is an aerodynamic surface, consisting of a small vane that creates a vortex. The objective of the project is to determine the drag reduction by using different VG, ranging from 60 km/h to 120 km/h that designed by Computational Aided Design (CAD) in (CREO 2.O).

Vortex generator themselves create drag, but they also reduce drag by preventing flow separation at downstream. The overall effect of vortex generators can be calculated by totaling the positive and negative effects. Drag force value can be obtained by using CFX. Besides that, CFX simulation results such as contour plot also used to analyze the characteristic of streamline flow at the rear end of FWV model. Comparison of drag force values with various vortex generator is to be done to achieve the project objectives.

Keywords: Drag force, vortex generators, CFD.

I. INTRODUCTION

Most of us don't think of air or wind as a wall. At low speeds and on days when it's not very windy outside, it's hard to notice the way air interacts with our vehicles. But at high speeds, and on exceptionally windy days, air resistance (the forces acted upon a moving object by the air -- also defined as drag) has a tremendous effect on the way a car accelerates, handles and achieves fuel mileage. So we have designed different shape of vortex generators to overcome these problems and the drag force reduction achieved by our vortex generators is compared and shown below.

II. EQUATION FOR DRAG FORCE

Drag is the aerodynamic force that opposes a vehicle's motion through the air. Drag is generated by every part of the vehicle. Drag is a mechanical force. It is generated by the interaction and contact of a solid body with a fluid (liquid or gas). For drag to be generated, the solid body must be in contact with the fluid. If there is no fluid, there is no drag. Drag is generated by the difference in velocity between the solid object and thefluid. There must be motion between the object and the fluid. If there is no motion, there is no drag. In fluid dynamics, the drag equation is a formula used to calculate the force of drag experienced by an object due to movement through a fully enclosing fluid.

$$F_D = \frac{1}{2}\rho v^2 C_D A$$

Where, C is the drag coefficient, A is the area of the object facing the fluid, and ρ is the density of the fluid.

A. Vortex Generators

A vortex generator (VG) is an aerodynamic device, consisting of a small vane usually attached to a lifting surface (or airfoil, such as an aircraft wing or a rotor blade of a wind turbine. VGs may also be attached to some part of an aerodynamic vehicle such as an aircraft fuselage or a car.

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B. Models of Vortex Generators

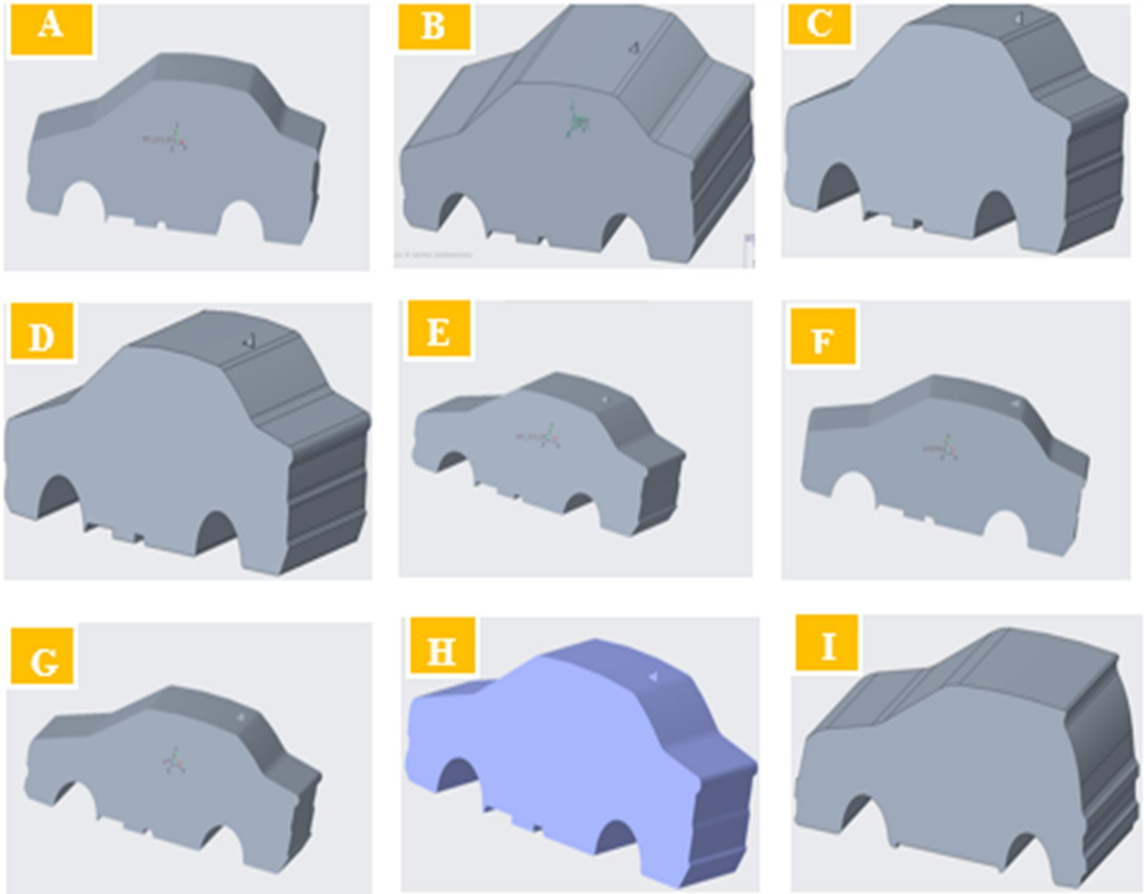

Figure 1 (A) Without VG - Sedan (B) Triangular VG - Sedan (C) Delta VG - Sedan (D) Parabolic VG - Sedan (E) Arrow VG - Sedan (F) Circle VG - Sedan (G) Doublet VG - Sedan (H) Stepped VG - Sedan (I) Without VG - Hatchback

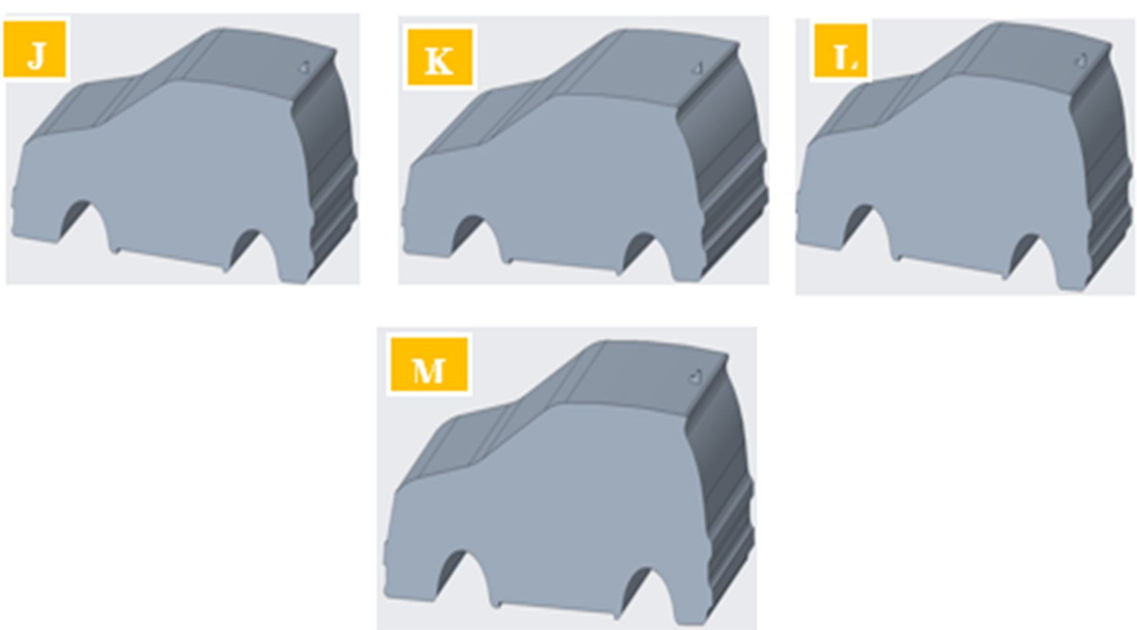

Figure 2 (J) Triangular VG – Hatchback (K) Delta VG - Hatchback (L) Parabolic VG - Hatchback (M) Stepped VG - Hatchback

IV. CFD ANALYSIS OF VORTEX GENERATORS

A. CFD Analysis Results of Drag Force Velocity and Pressure Gradient for Sedan Type Cars

Drag analysis of sedan cars without VG's results 520N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

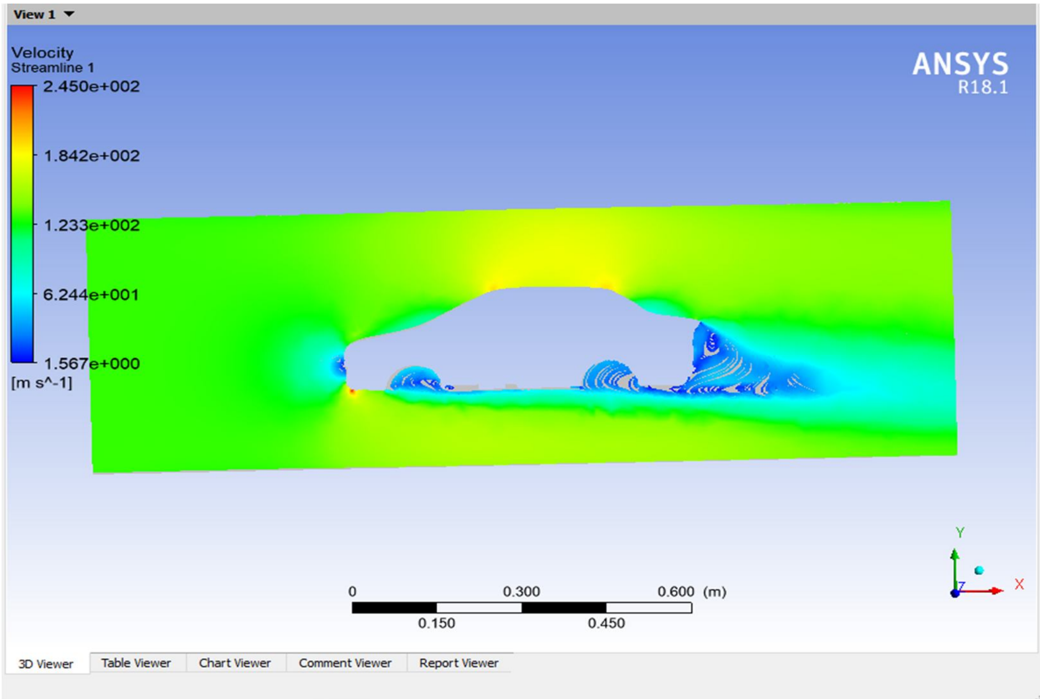

Figure 3 Sedan Type Cars without Vortex Generator

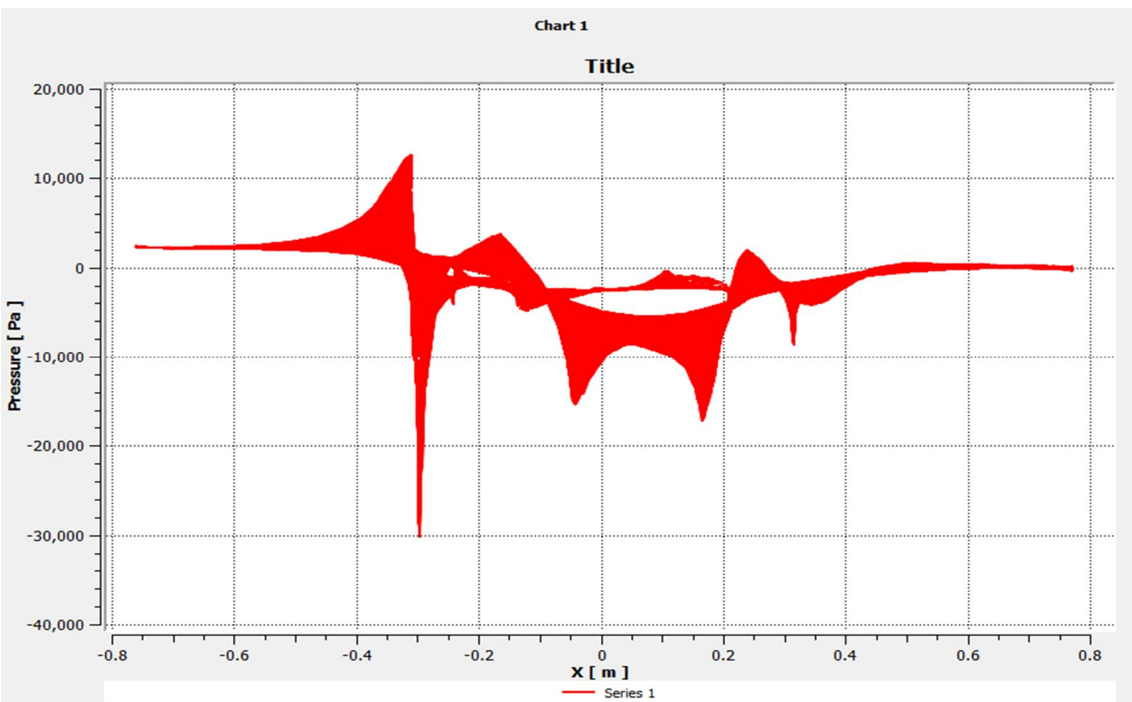

Figure 4 Pressure Gradient for Sedan Type Cars without Vortex Generator

Drag analysis of sedan cars with triangular vg results 461N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

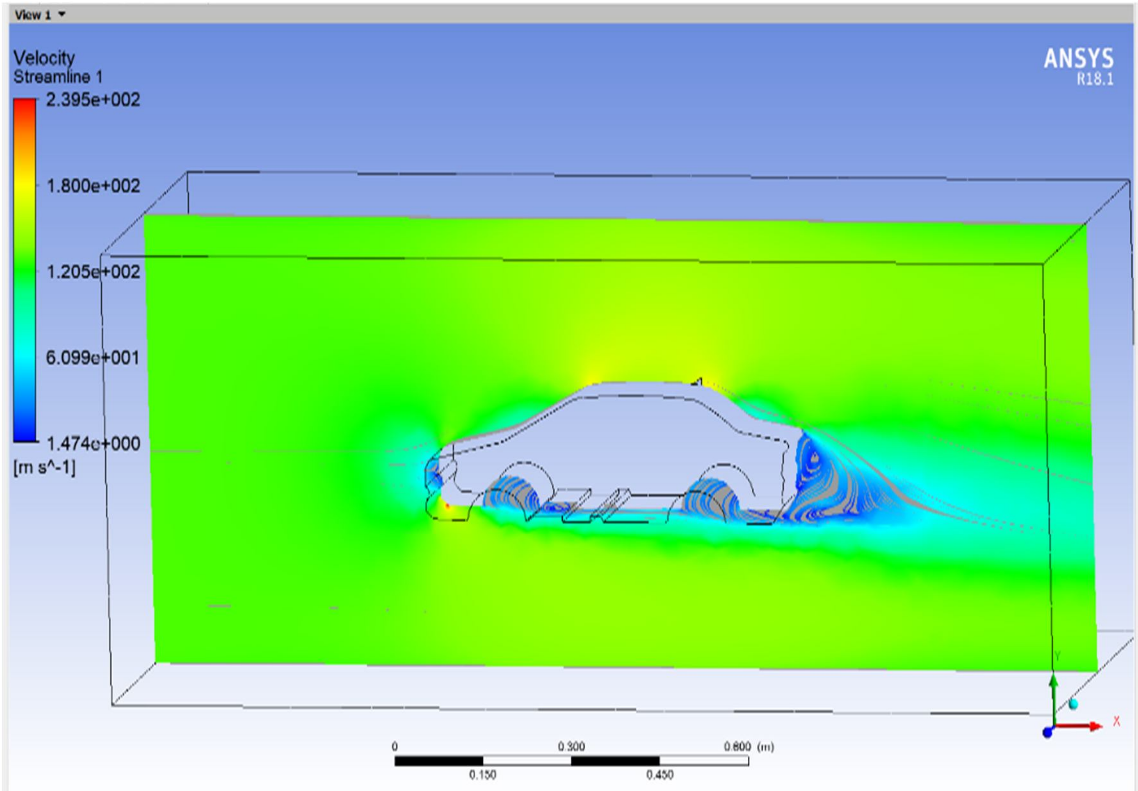

Figure 5 Triangular Vortex Generator of Sedan Type Cars

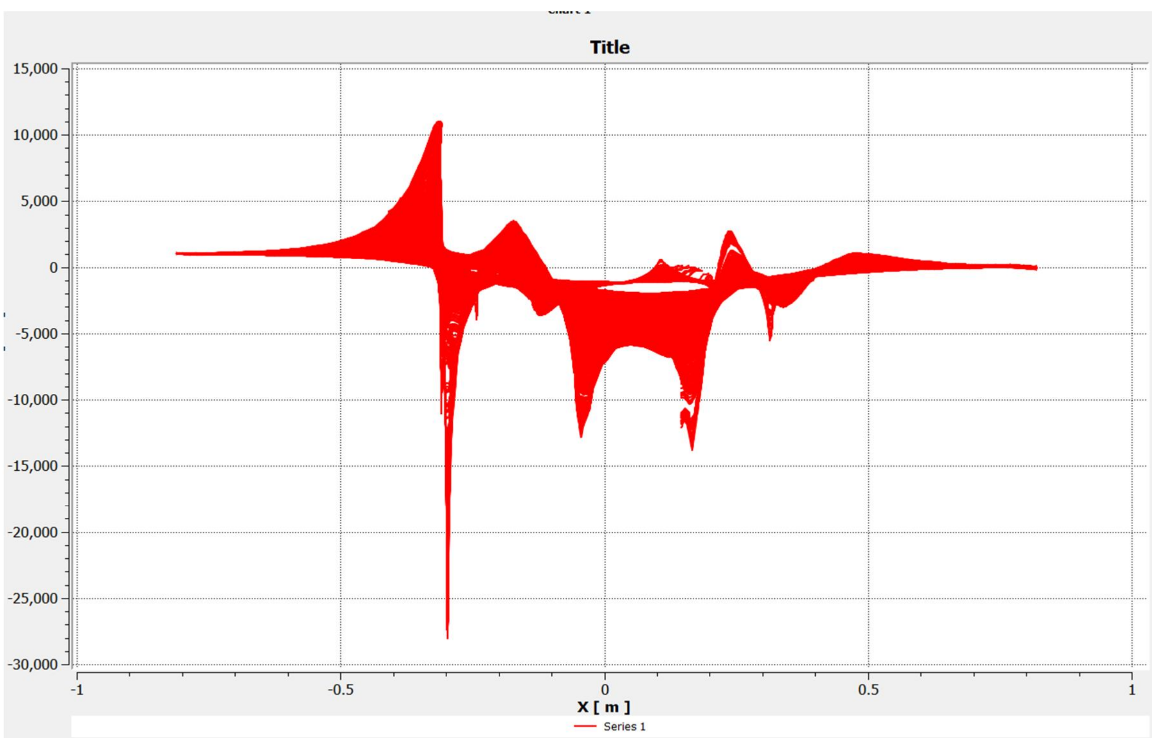

Figure 6 Pressure Gradient for Triangular Vortex Generator of Sedan Type Cars

Drag analysis of sedan cars with delta vg results 460N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

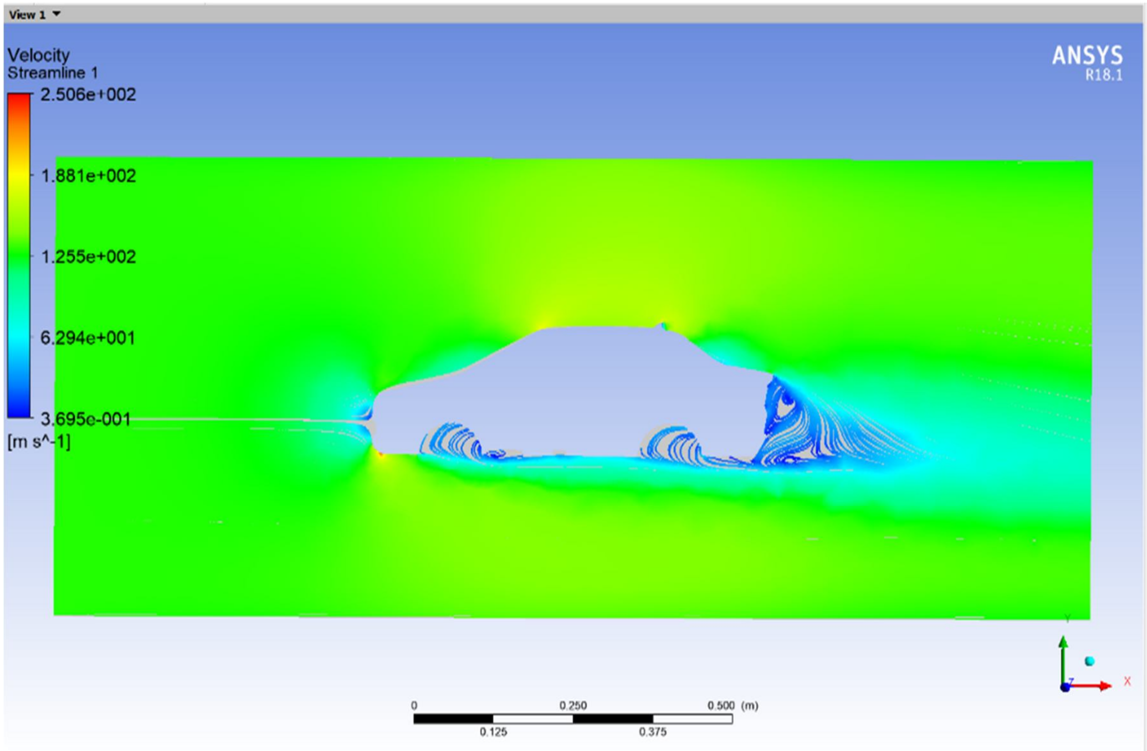

Figure 7 Delta Vortex Generator of Sedan Type Cars

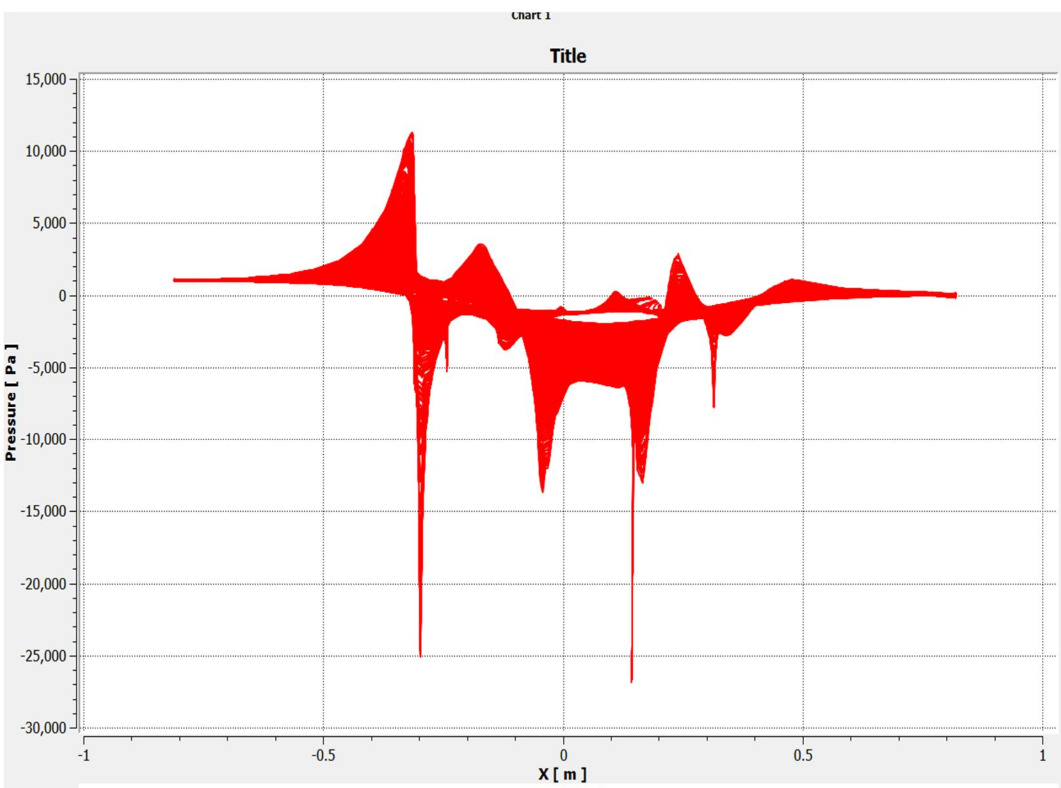

Figure 8 Pressure Gradient of Delta Vortex Generator for Sedan Type Cars

Drag analysis of sedan cars with parabolic vg results 455N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

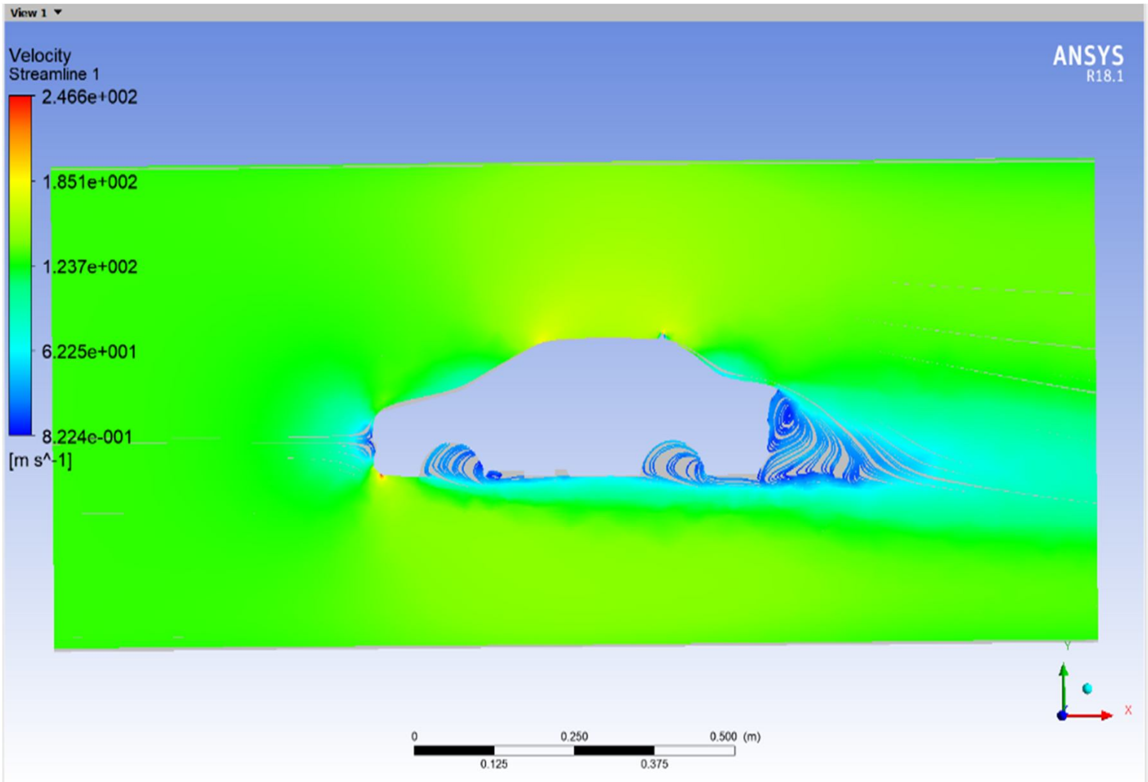

Figure 9 Parabolic Vortex Generator of Sedan Type Cars

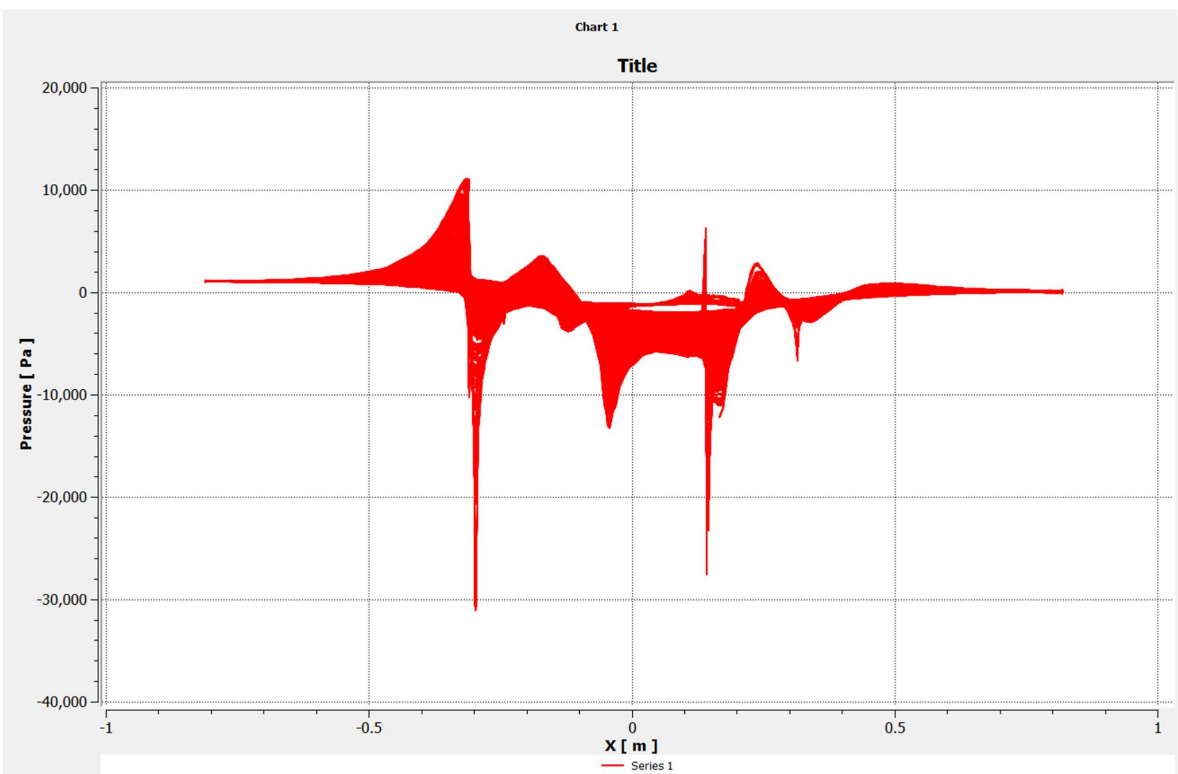

Figure 10 Pressure Gradient of Parabolic Vortex Generator for Sedan Type Cars

Drag analysis of sedan cars with doublet vg results 456N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

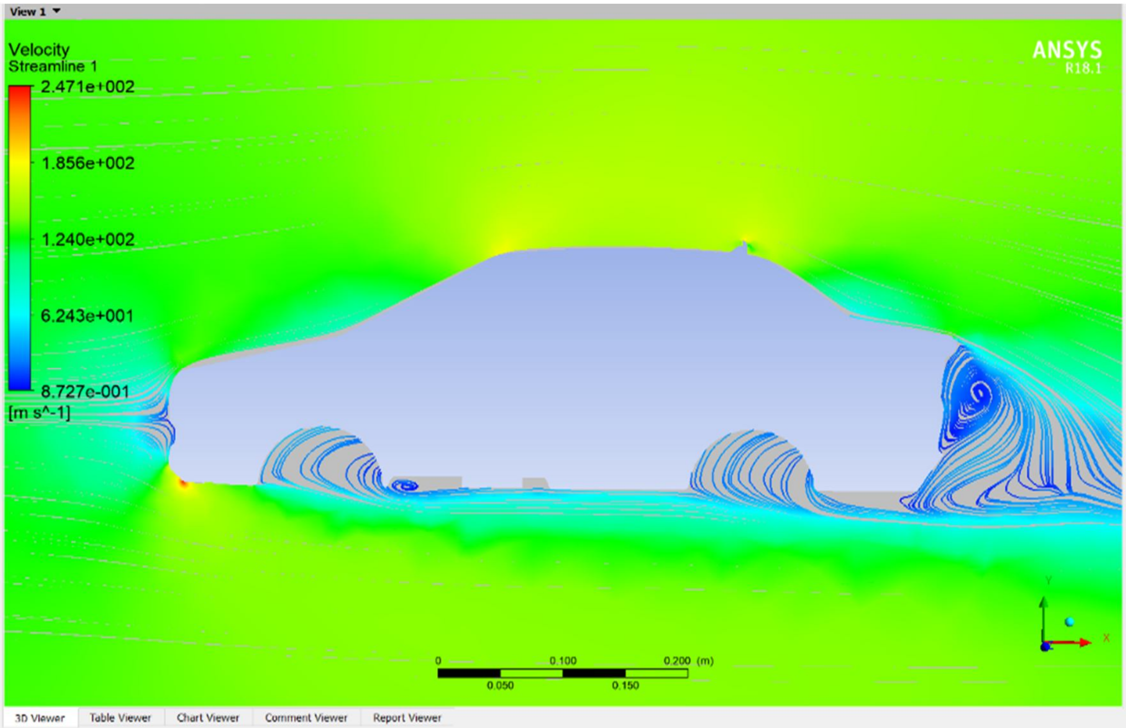

Figure 11 Arrow Vortex Generator of Sedan Type Cars

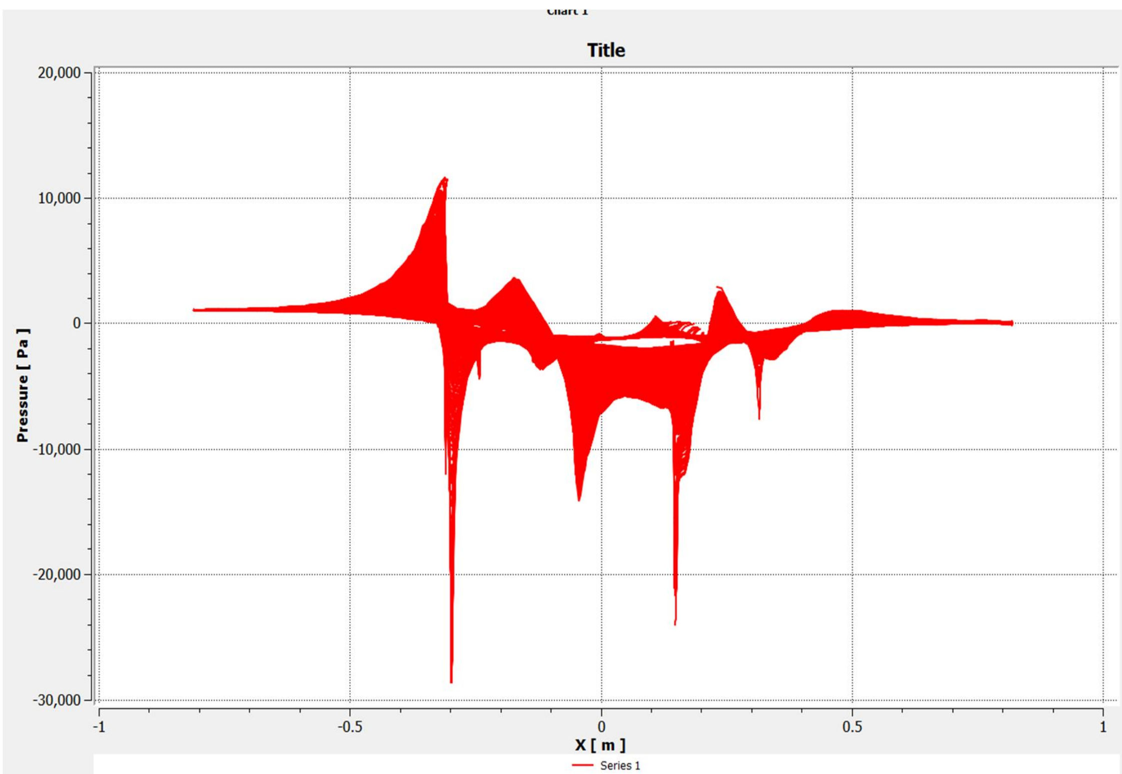

Figure 12 Pressure Gradient of Arrow Vortex Generator for Sedan Type Cars

Drag analysis of sedan cars with circle vg results 455N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

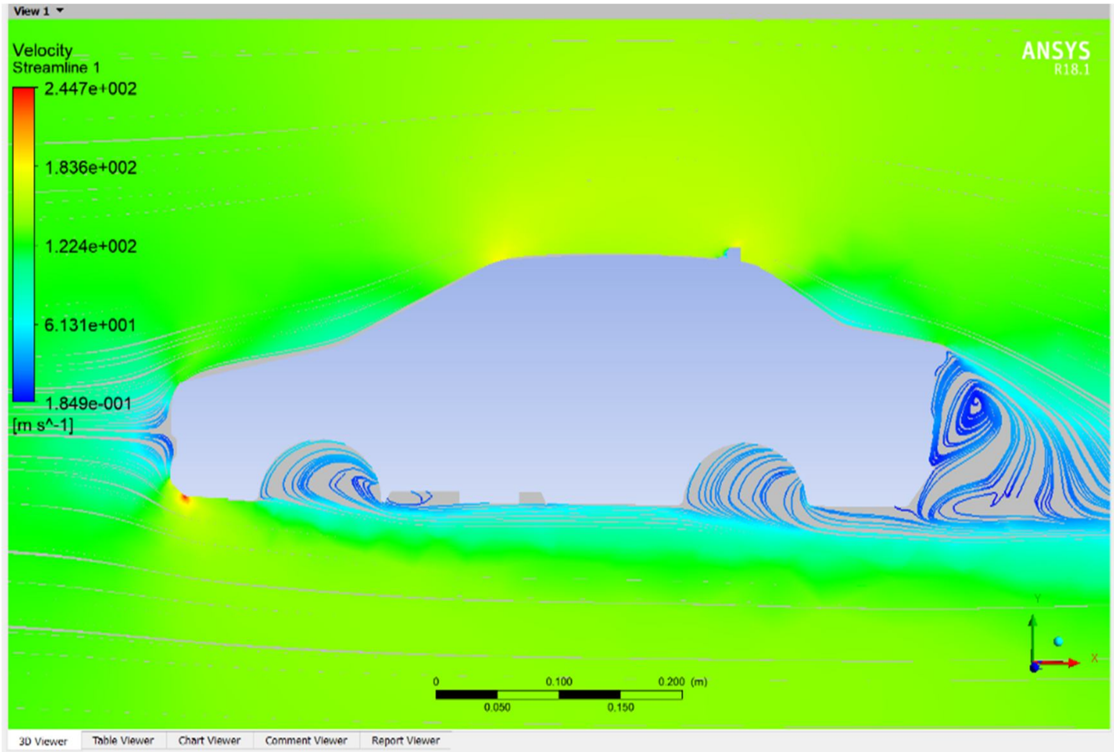

Figure 13 Doublet Vortex Generator of Sedan Type Cars

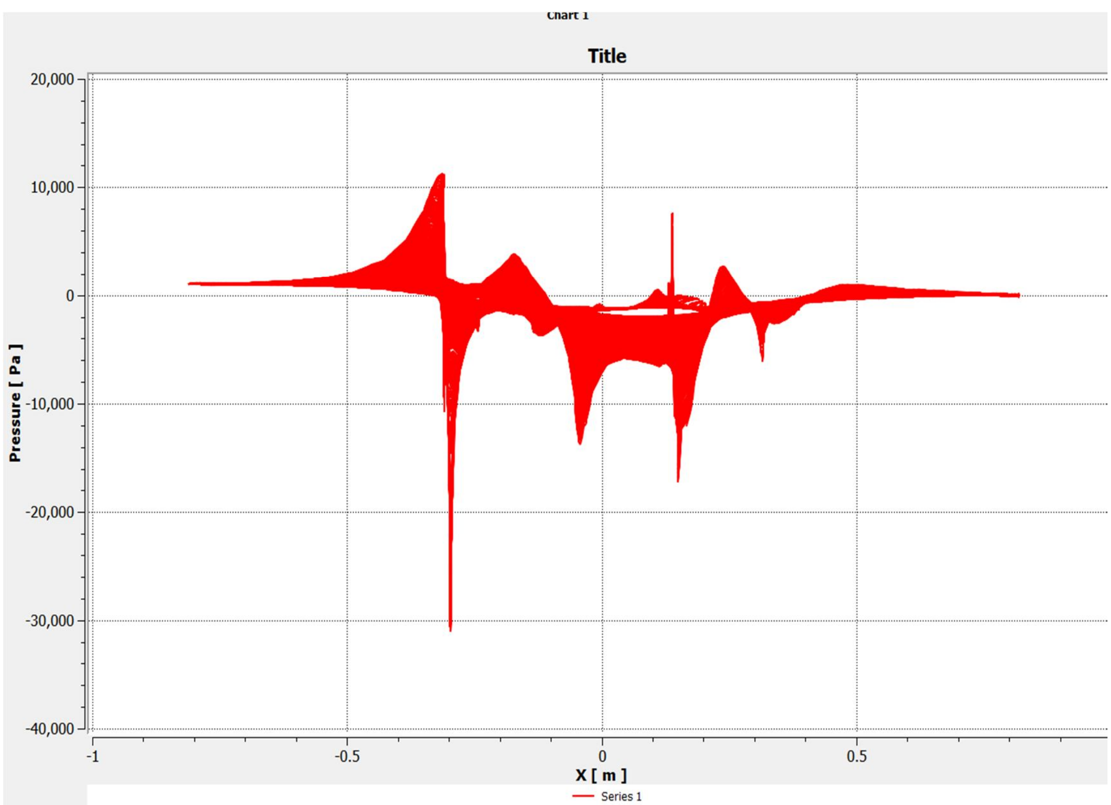

Figure 14 Pressure Gradient of Doublet Vortex Generator for Sedan Type Cars

Drag analysis of sedan cars with stepped vg results 359N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal Fluid values.

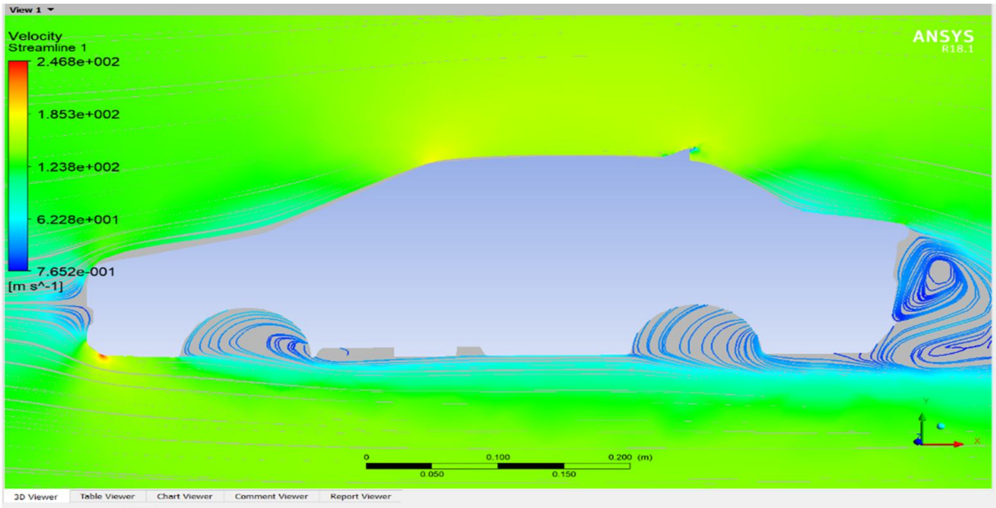

Figure 15 Circle Vortex Generator of Sedan Type Cars

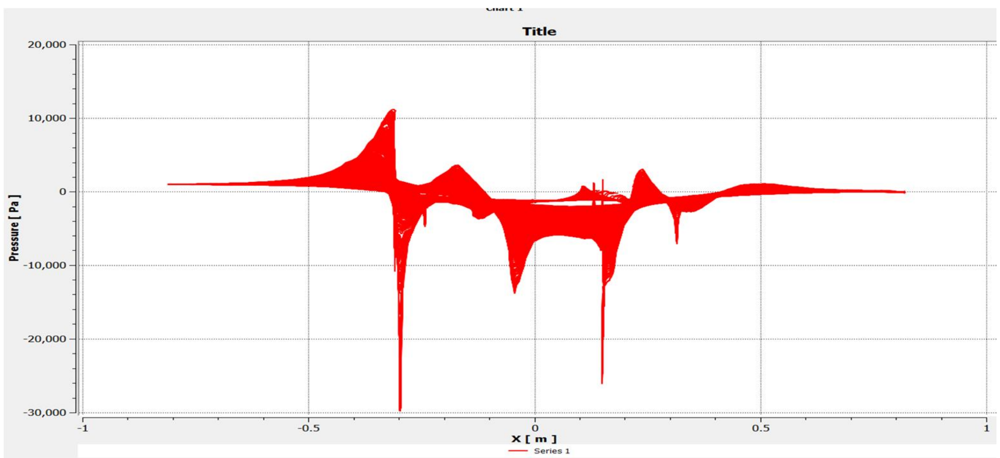

Figure 16 Pressure Gradient of Circle Vortex Generator for Sedan Type Cars

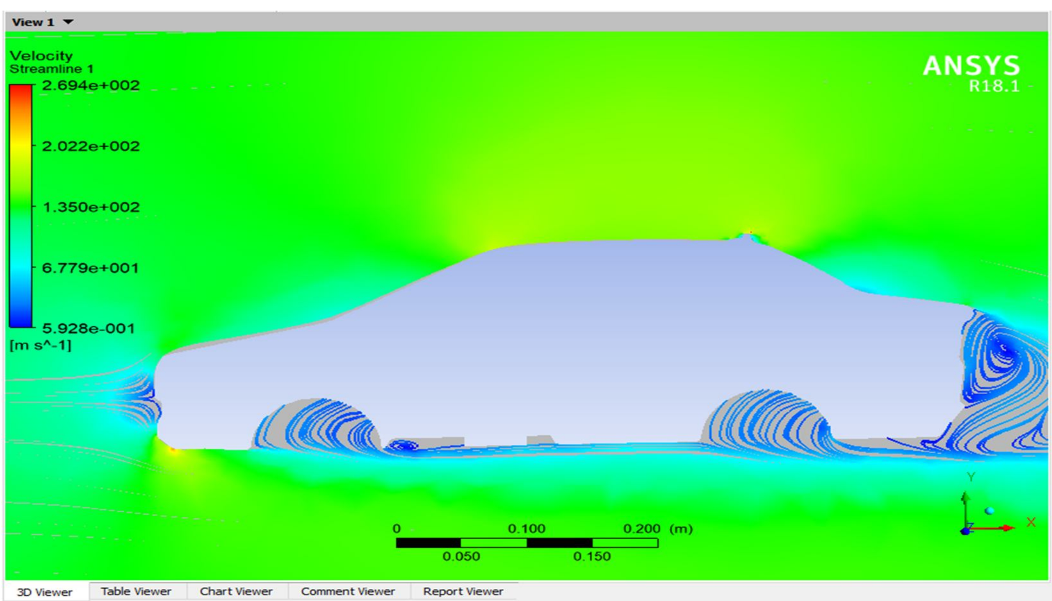

Figure 17 Stepped Vortex Generator of Sedan Type Cars

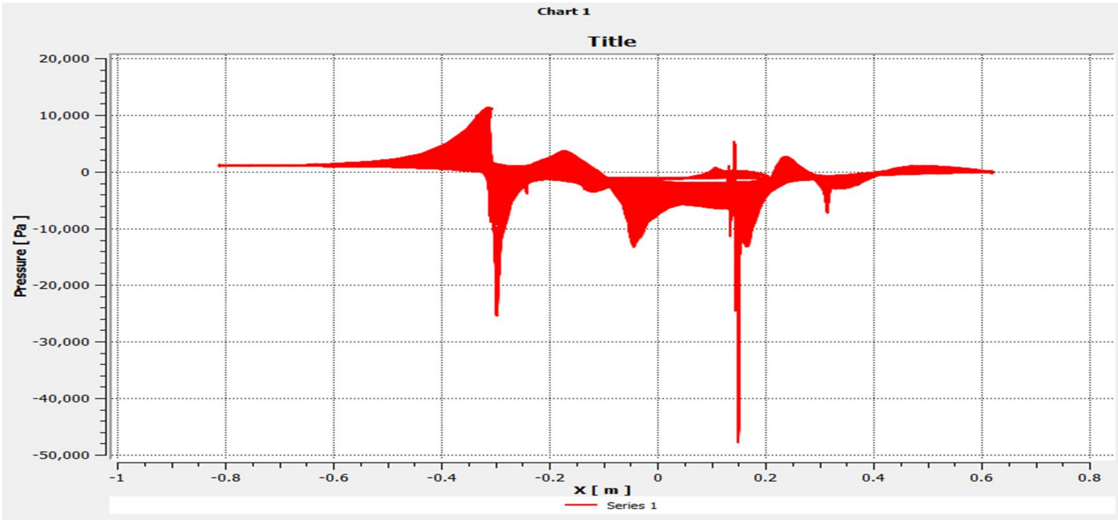

Figure 18 Pressure Gradient of Stepped Vortex Generator for Sedan Type Cars

B. CFD Analysis Results of Drag Force Velocity and Pressure Gradient for Hatchback Type Cars

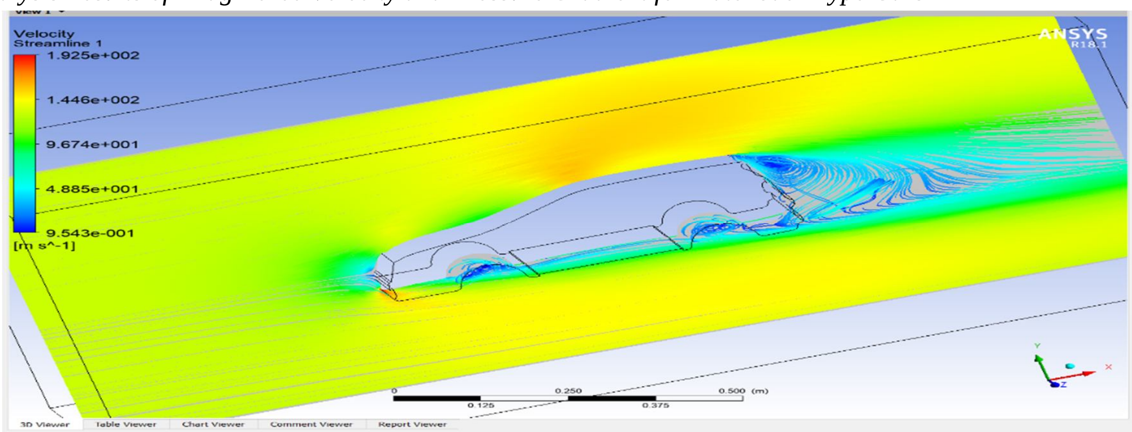

Figure 19 Without Vortex Generator of Hatchback Type Cars

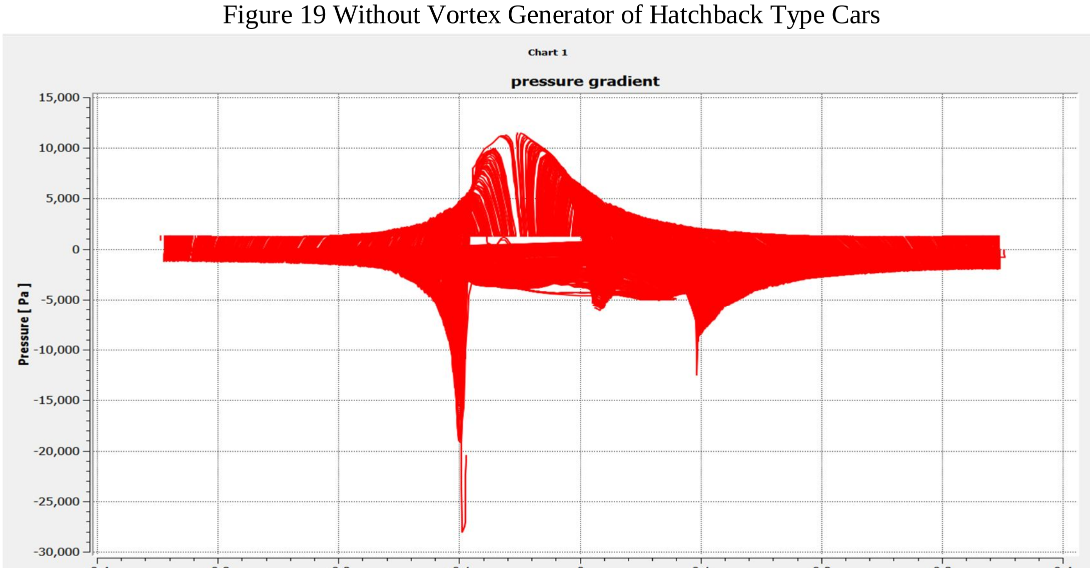

Figure 20 Pressure Gradient of Without Vortex Generator for Hatchback Type Cars

Drag analysis of hatchback cars with without vg results 530N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

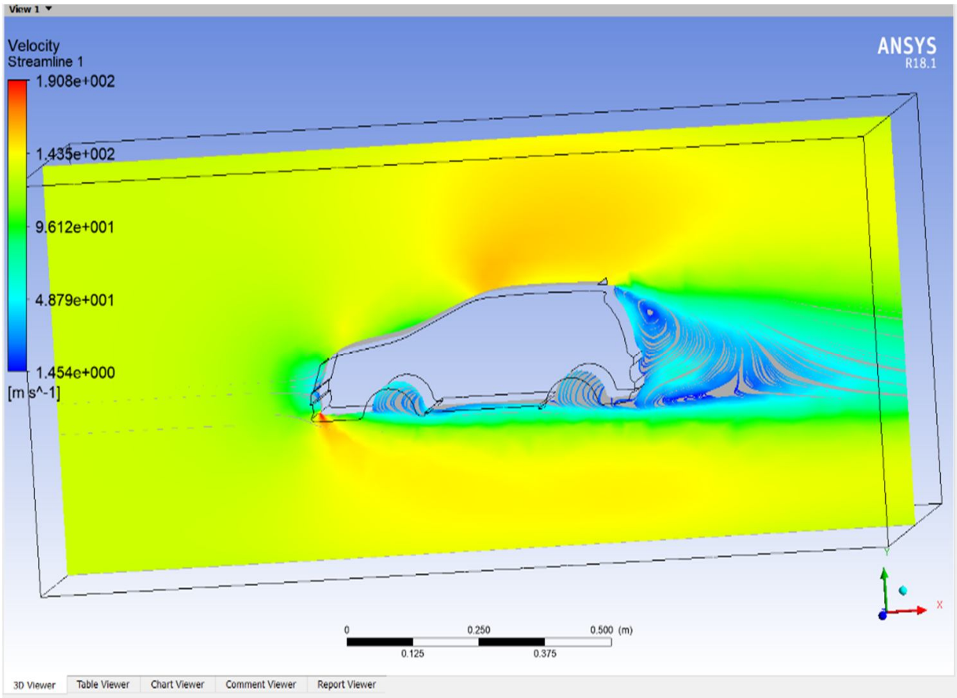

Figure 21 Triangular Vortex Generator of Hatchback Type Cars

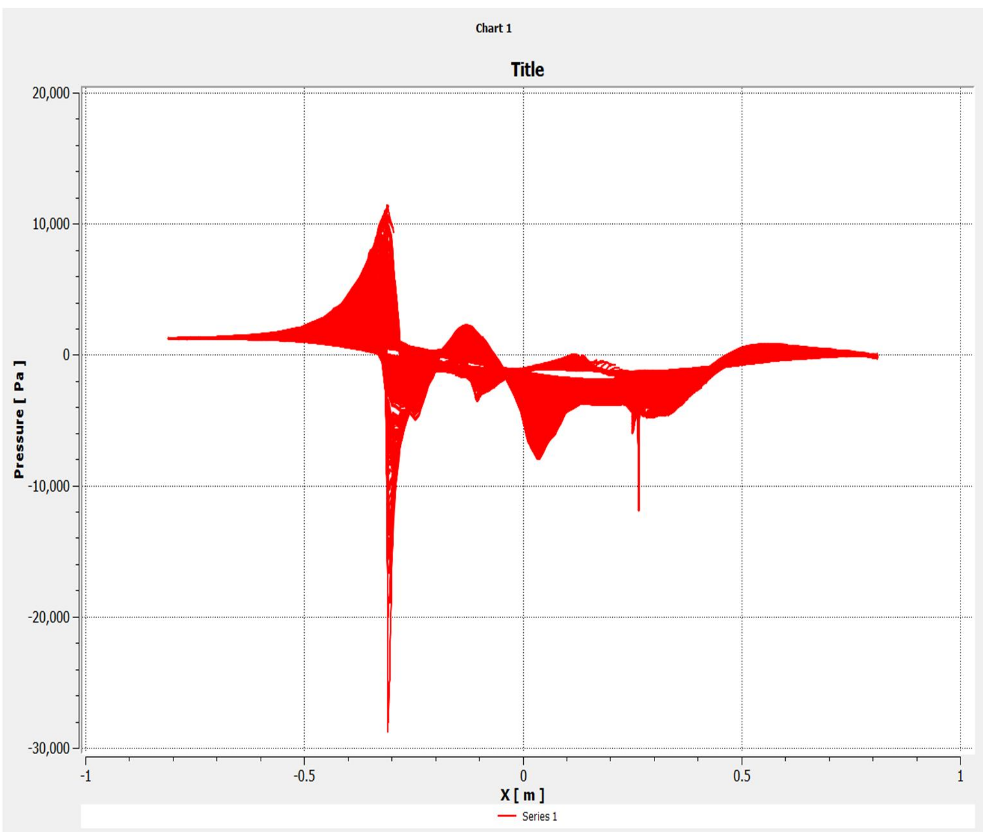

Figure 22 Pressure Gradient of Triangular Vortex Generator for Hatchback Type Cars

Drag analysis of hatchback cars with triangular vg results 525N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

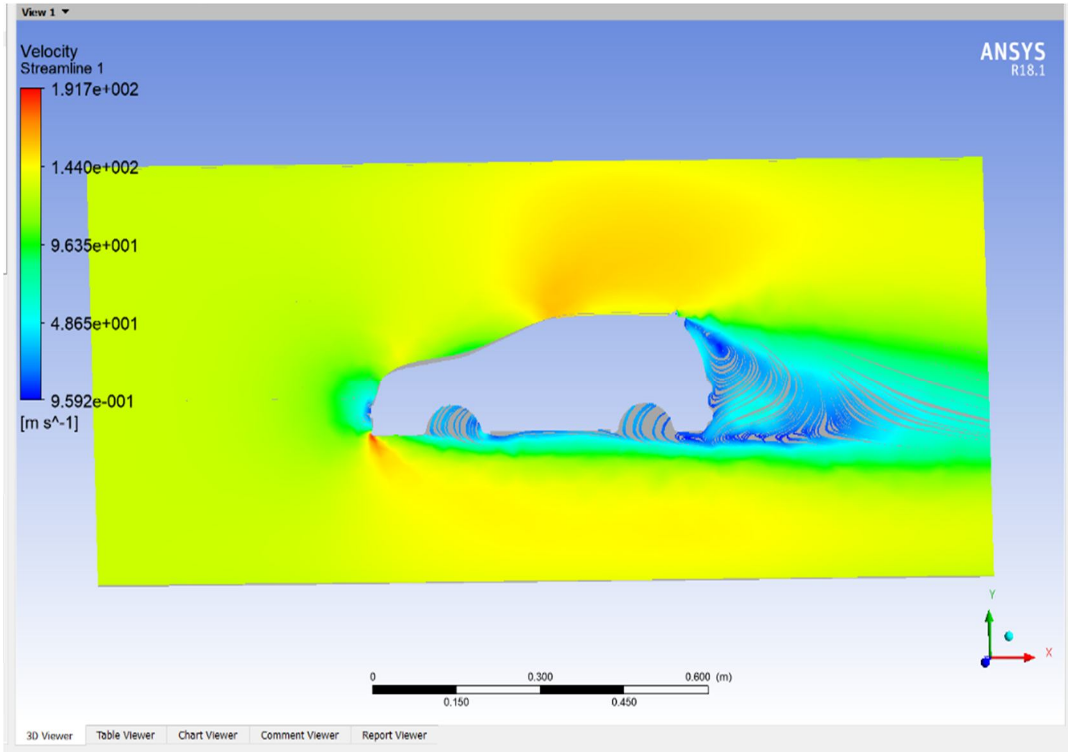

Figure 23 Delta Vortex Generator of Hatchback Type Cars

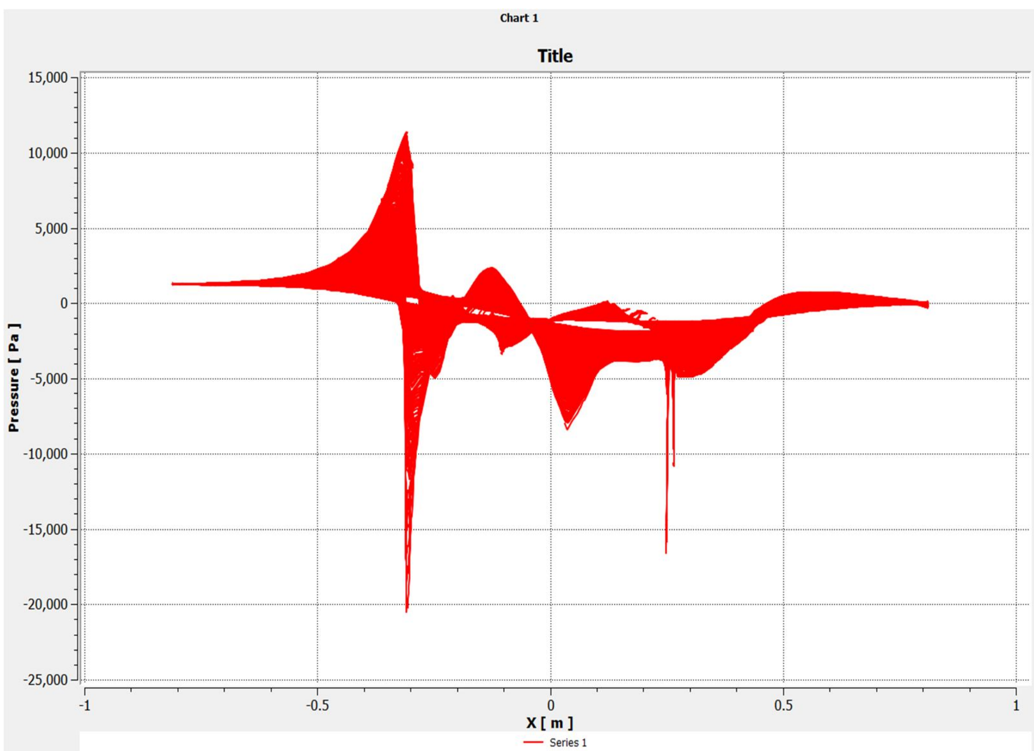

Figure 24 Pressure Gradient of Delta Vortex Generator for Hatchback Type Cars

Drag analysis of hatchback cars with delta vg results 522N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

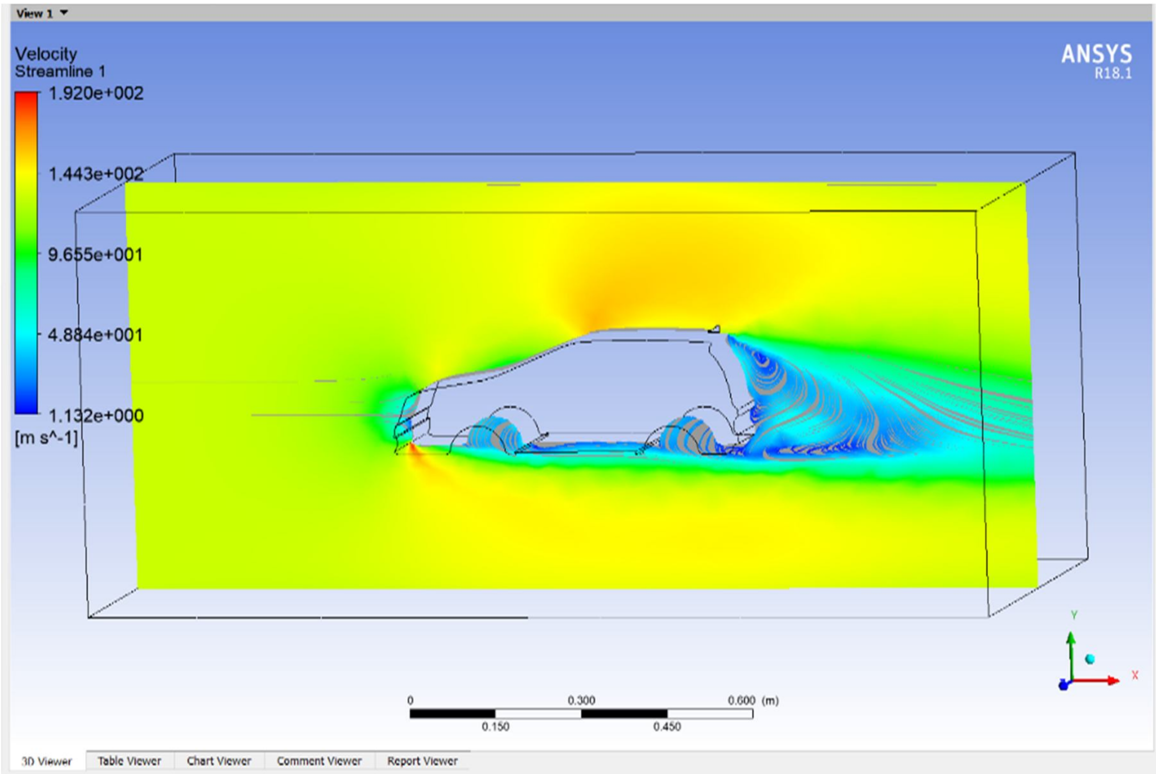

Figure 25 Parabolic Vortex Generator of Hatchback Type Cars

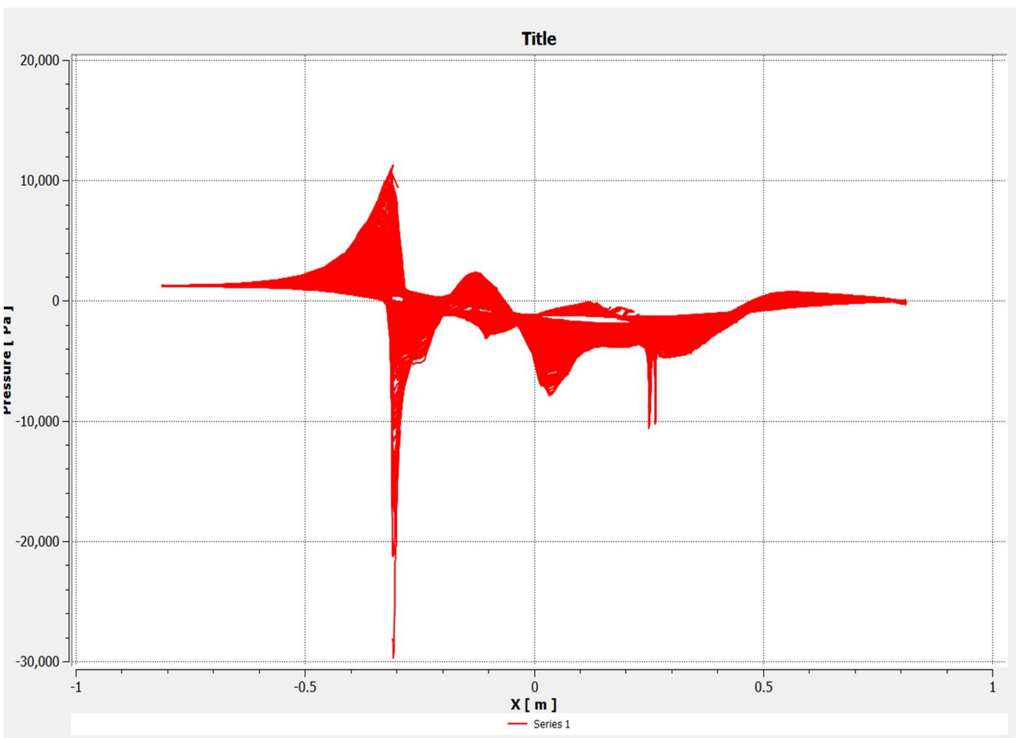

Figure 26 Pressure Gradient of Parabolic Vortex Generator for Hatchback Type Cars

Drag analysis of hatchback cars with parabolic vg results 500N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

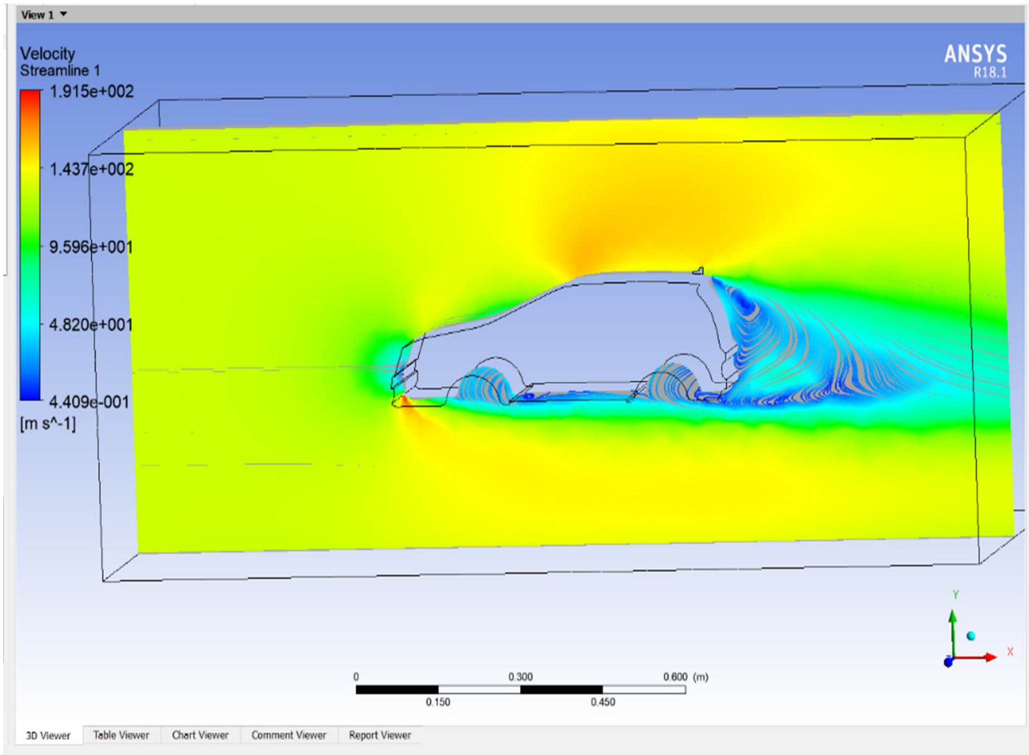

Figure 27 Stepped Vortex Generator of Hatchback Type Cars

Drag analysis of hatchback cars with stepped VG results 525N of drag force in numerical. This value is taken from calculation section under force parameter, which is measured from normal fluid values.

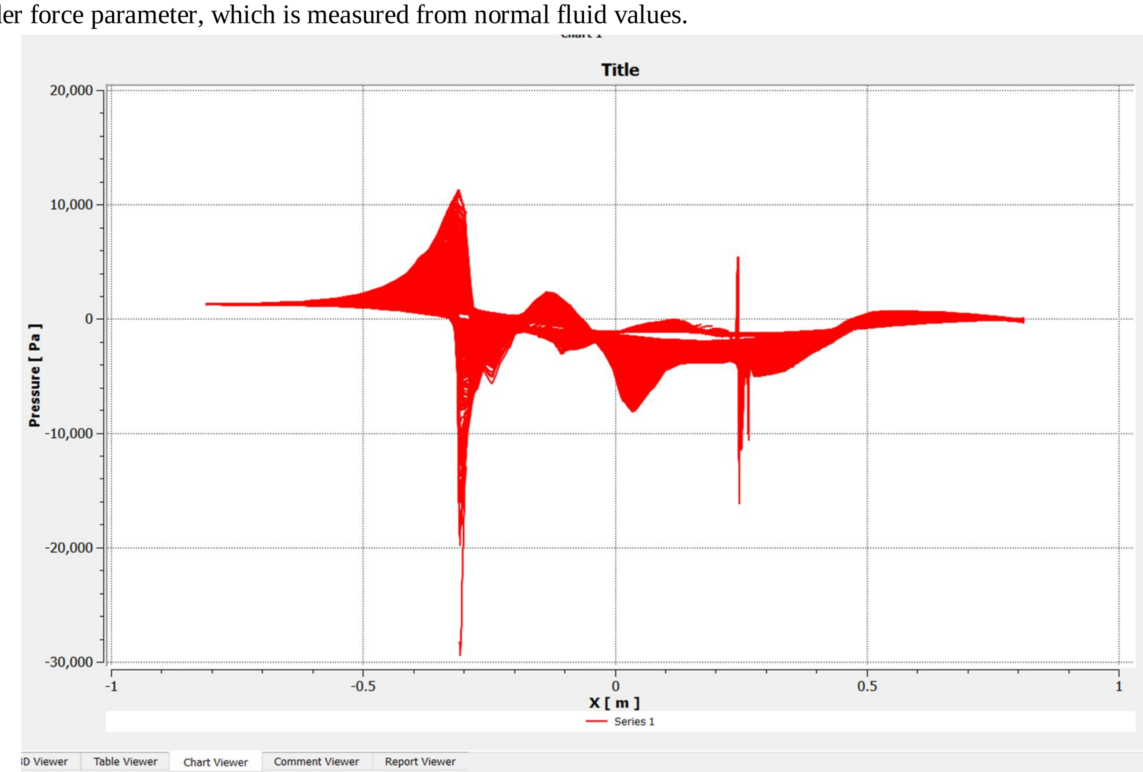

Figure 28 Pressure Gradient of Stepped Vortex Generators for Hatchback Type Cars

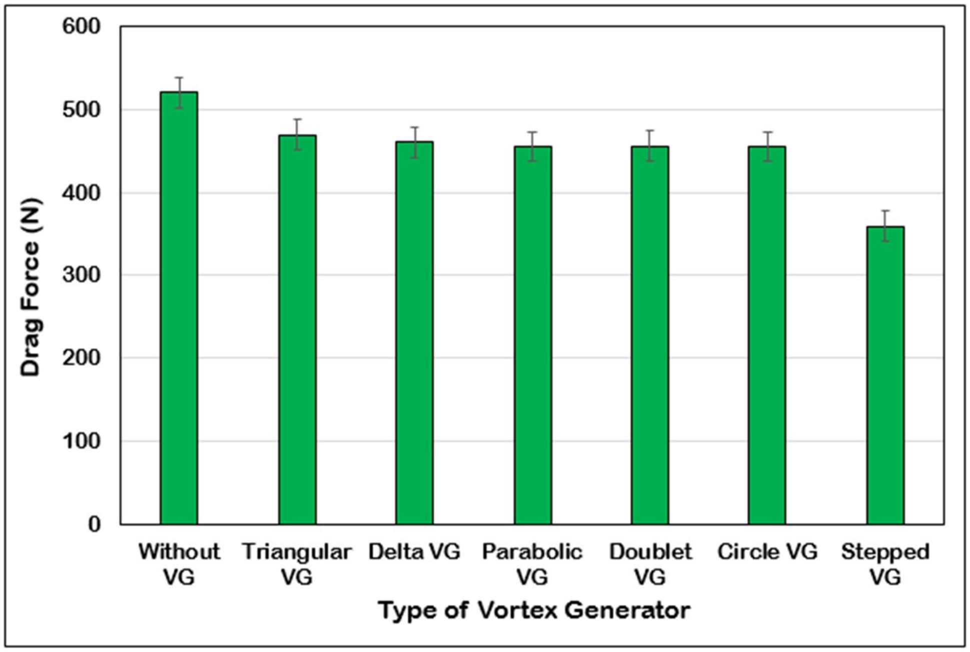

Figure 29 Variation on Drag Force for Sedan Type Cars

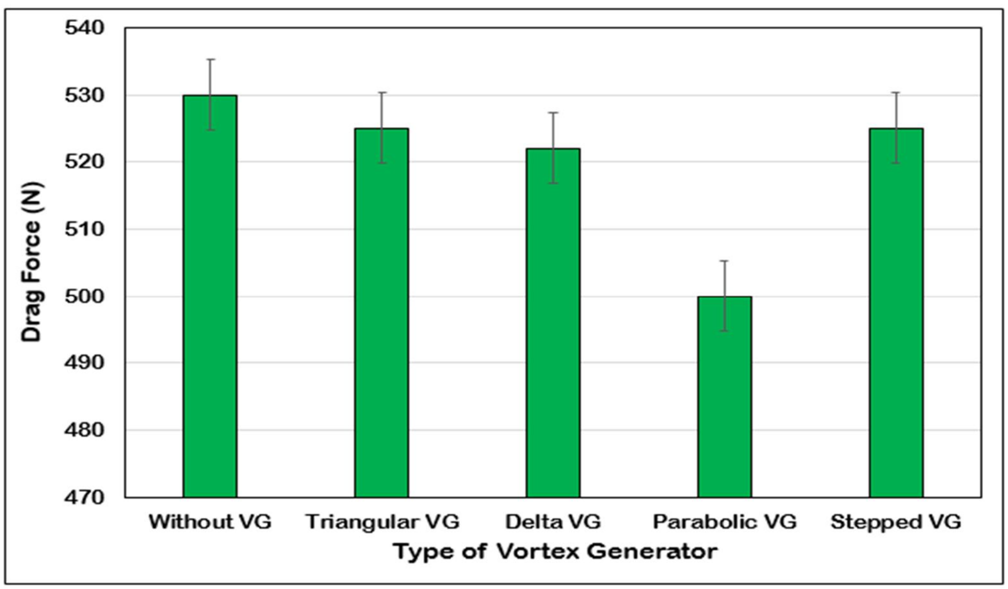

Figure 30 Variation on Drag Force for Hatchback Type Cars

V. CONCLUSION

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 aerodynamics and hydrodynamics surfaces which delay flow separation and keep the local flow attached for as long as possible. A When the air foil 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 air foil surface, delays local flow separation and aerodynamics stalling, thereby improving the effectiveness of wings and control surface, such as flaps, elevators, ailerons, and rudders. In this project we using different shapes of vertex generator, and minimizing flow separation and also drag force vortex generator (VG) consisting of a small vane usually attached to a lifting. Values for all shapes and also find out pressure gradient and make compare with all shapes values and tell result about which shapes will give minimum drag force values.

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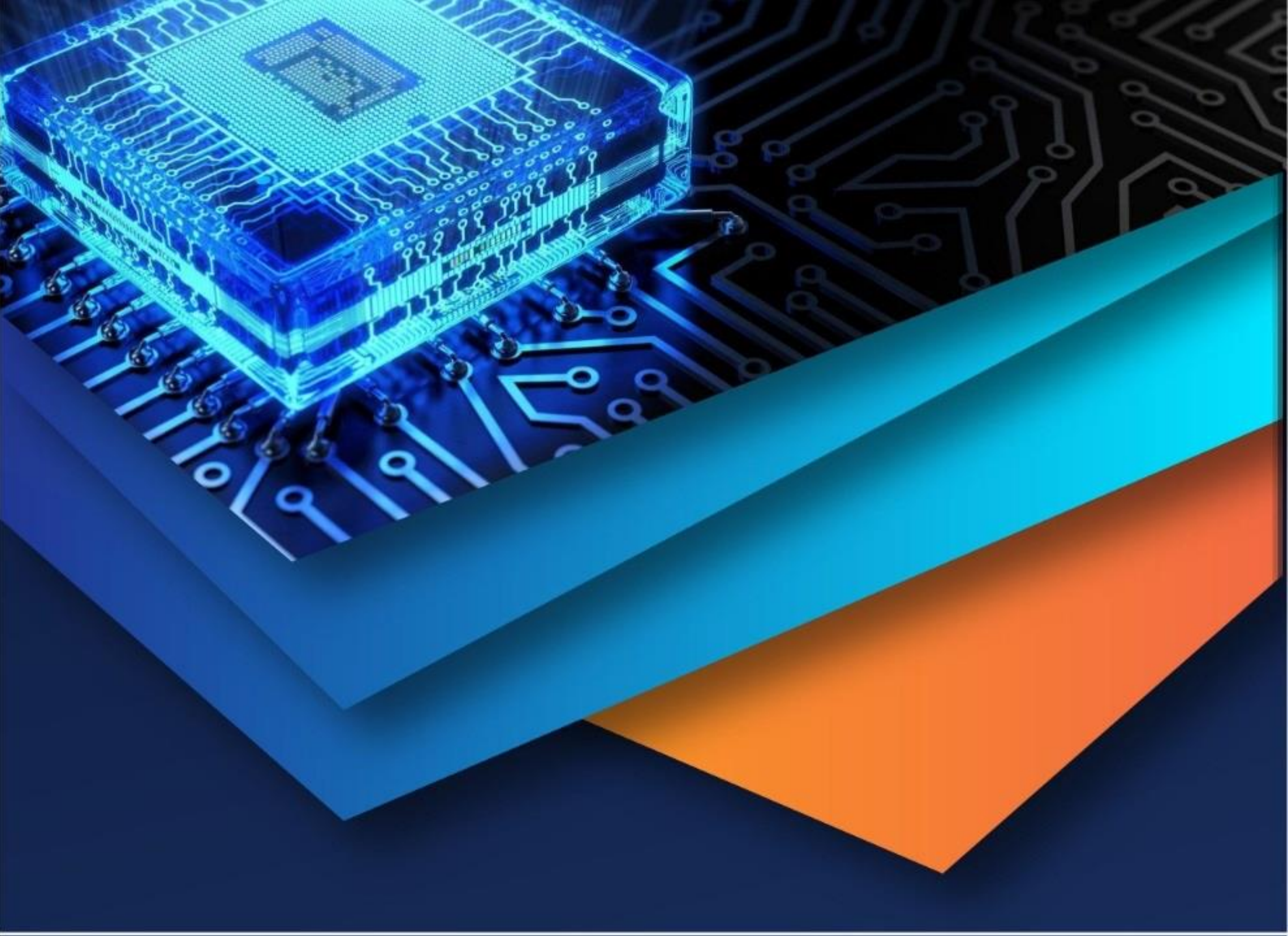

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