Experimental Investigation on Aerodynamic Drag Reduction with Splitter Plate Technique using Wind tunnel

R. Ramanjaneyulu[#1], K. Nagarjuna[*2], G. Radha Krishna[#3]
[#1] M.Tech scholar, #2 Assistant professor, department of mechanical, Vignan's lara institute of technology and sciences, JNTU-K, Guntur, AP, India.
[#3] Research Associate, School of mechanical engineering, VIT University ,Vellore, TN, India

Abstract

The present work goes on with the design and analysis of splitter plate with rectangular cross section by varying length for reducing the drag force. Aerodynamic force plays an important role in vehicle performance and its stability when vehicle reaches more speed. Nowadays the maximum speed of car has been increased above 180 km/hr but at this speed the car has been greatly ascendancy by drag and lift forces. Drag force mainly reduces the speed of an automobile and also reduces the efficiency at high speeds. By using the splitter plate the drag force can be reduced. This device can be tested in the low speed wind tunnel for coefficient of pressure and coefficient of drag and finally the design of the model with less coefficient of drag should be considered as better one compared to other.

Keywords — *Aerodynamic Drag, Coefficient of Drag, Splitter plate, Wind tunnel.*

I. INTRODUCTION

The objective of the present report is to fold reviewing the possible methods for the reduction of the drag of an automobile. The subject of drag reduction is an interesting problem with a wide range of applications. Because of the difficulties associated with the theoretical analysis, the study of drag reduction has been almost experimental.

Hence in this project we take a rectangular cylinder for the investigation. The selected configuration has the advantage of having nearly uniform base pressure, unlike a cylinder, which has a wide variation of pressure in the base region. Therefore it is expected that increase in base pressure will be the major Cause of drag reduction and that the magnitude of the drag reduction would be significant.

Several investigations have been reported on drag reduction of an automobile. Bao Hai-Tao et al [1] discussed study on different rear windscreen angles on passenger car and submitted in the 7th International Conference on Computer Science and Education on July, 2012 in Melbourne. P.N.Sevlaraju, Dr.M.N.Parammasivam, Shankar, Dr.G.Devaradjane et al [2] implemented the vortex generator as a aerodynamic add on device at rear portion of the vehicle and reduced the coefficient of drag value. R.B.Sharma, Ram Bansal et al [3] concluded that the addition of tail plates method drag-coefficient is reduced by 3.87% and lift coefficient also reduced by 16.62% in head-on wind. Sathish Kumar K et al[4] investigated on Enhancement of Aerodynamic Characteristics In Automobiles. The aerodynamic drag force acting over the car body is analysed by considering Computational Fluid Dynamics (CFD) analysis and results were endorse experimentally by conducting the wind tunnel test. The drag force acting over the car body is determined by both numerical and experimental method. Ye jian, Yan Xu et al [5] carry the investigation on Aerodynamic Optimization Research on apparent Shape for a Sedan Based car on Numerical Simulation and the drag coefficient and the aerodynamic characteristics around the model were achieved with the analysis of velocity and pressure distribution and they submitted it in 2013 Fourth International Conference on Digital Manufacturing & Automation.

The Wind angles also play an important role in effective performance of automobile. The aerodynamics in open spaces becomes even more involved when the automobile runs in highways. Ian Hong and Larsson investigated the outer flow around automobile, result show that the turbulence behind the automobile has great effect on the automobile aerodynamics. The research mainly focus the numerical flow around the car body with multi angles of wind velocity to car axis in range of 0-30°.The dimensions of an automobile 4350m×1680m×1480m in lenght×width×height respectively. With the increase in wide angles there will be increase in coefficient of flow resistance. Due to this increase in wind angles there will be safe running of automobile in windy days and windy areas.

II. EXPERIMENTAL SETUP AND PROCEDURE

A. *Experimental Setup*

The experiments were conducted in a low speed wind tunnel with 30×60 cm rectangular test section of length 150 cm. The model which is shown in the below was mounted across the width at the middle of the test section. Pressure taps for measuring the surface pressure distribution were provided at the middle section of the model, along the circumference. The splitter plates were made from 0.8mm thick aluminium sheets.

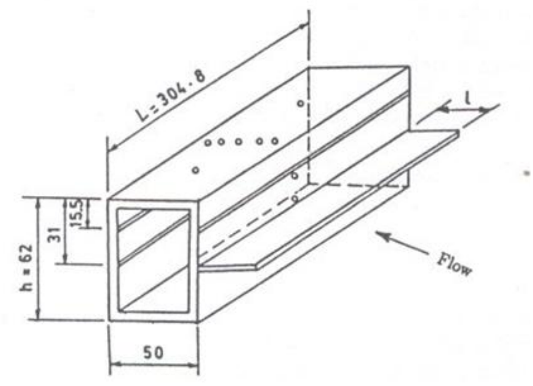

Fig. 1 Schematic of Experimental Model.

The measurements were made at free stream velocities 10.31,15.09,20.09 and 25.25m/s to ensure the reduction of drag. The Reynolds numbers for these speeds based on the cylinder base height, are 0.438×10^5, 0.641×10^5, 0.86×10^5, and 1.072×10^5. Splitter plate lengths used were h /2, h, 3h /2, and 2h. Total drag which is acting on the splitter plate was determined using the strain gauge in the low speed wind tunnel. We were provide the water manometer for measure the pressure. They are accurate up to ±1%. The length measurements are accurate up to ±0.1mm.

Fig. 2 Photographic View of Low Speed Wind Tunnel.

B. Experimental Procedure

- The scaled model of splitter plate can be placed in a low speed wind tunnel.
- A road like platform can be created inside the test section of the wind tunnel.
- The various forces acting over the surface of the model are Drag force, Lift force and Pitching moment are measured using strain gauge.

C. Formula Used

Coefficient of Drag

$$C_D=2\times F_D / e_\infty \times v_\infty\times v_\infty (A_P)$$

Average Base Pressure Coefficient

$$C_{Pb}= 2(P_b - P_\infty) /(e_\infty\times v_\infty\times v_\infty)$$

Reynolds Number

$$R_{eh}= (e_\infty\times v_\infty\times h) / \mu_\infty$$

III. RESULTS AND DISCUSSION

From Fig.3, the variation of coefficient of drag over the surface of model in the direction of flow in forward position at different splitter plate length h/2 ,h ,3h/2 ,2h.The plot shows that coefficient of drag for splitter plate l=62mm is having less drag when compared to the other three plates.

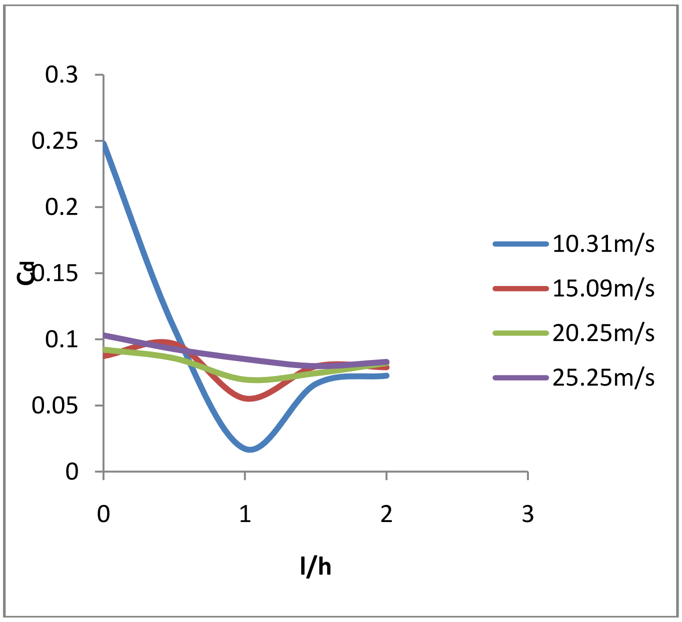

Fig. 3 Variation of Coefficient of Drag(Cd) With Splitter Plate Length Forward Position.

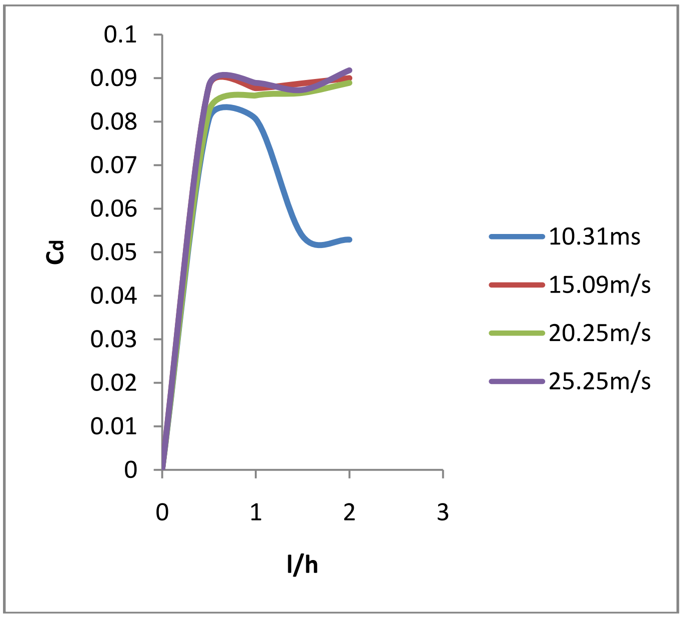

Fig. 4 Variation of Coefficient of Drag(Cd) With Splitter Plate Length Backward Position.

From Fig.4 the plot shows the variation of coefficient of drag over the surface of model in the direction of flow in backward position at different splitter plate length h/2 ,h ,3h/2 ,2h.The plot shows that the coefficient of drag is increasing with the increasing of splitter plate length.

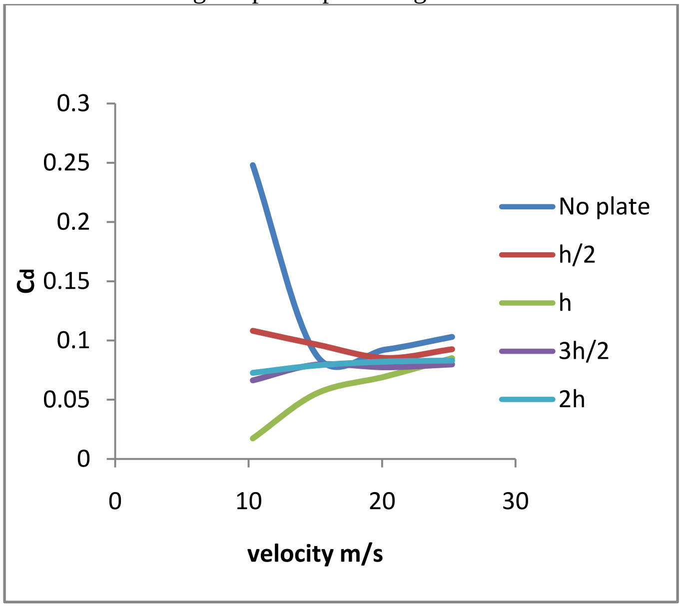

Fig. 5 Variation of Coefficient of Drag(Cd) With Velocity In Forward Position

From Fig.5 the plot shows the variation of coefficient of drag over the surface of model in the direction of flow at different velocities 10.31 m/s, 15.09 m/s, 20.25 m/s, 25.25 m/s velocities. The plot shows that the coefficient of drag is increasing with the increase of velocity and the model with no plate is decreases up to certain velocity and then increases.

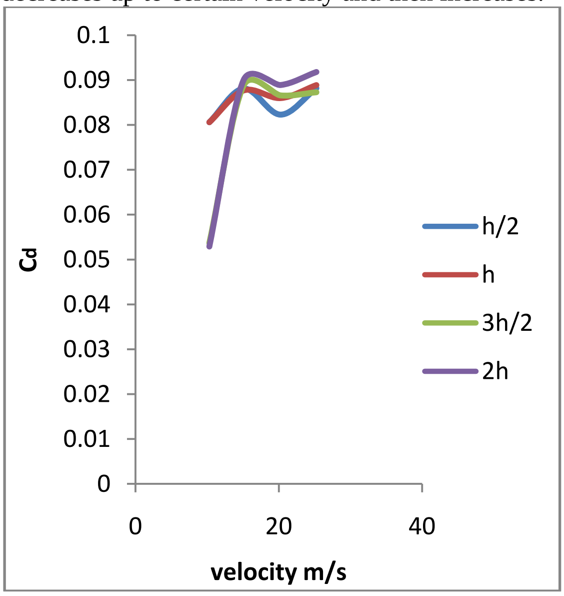

Fig. 6 Variation of Coefficient of Drag(Cd) with Velocity in Backward Position.

From Fig.6 the plot shows the variation of coefficient of drag over the surface of model in the direction of flow at different velocities 10.31 m/s, 15.09 m/s, 20.25 m/s, 25.25 m/s velocities. The plot shows that the coefficient of drag is increasing with the increase of velocity.

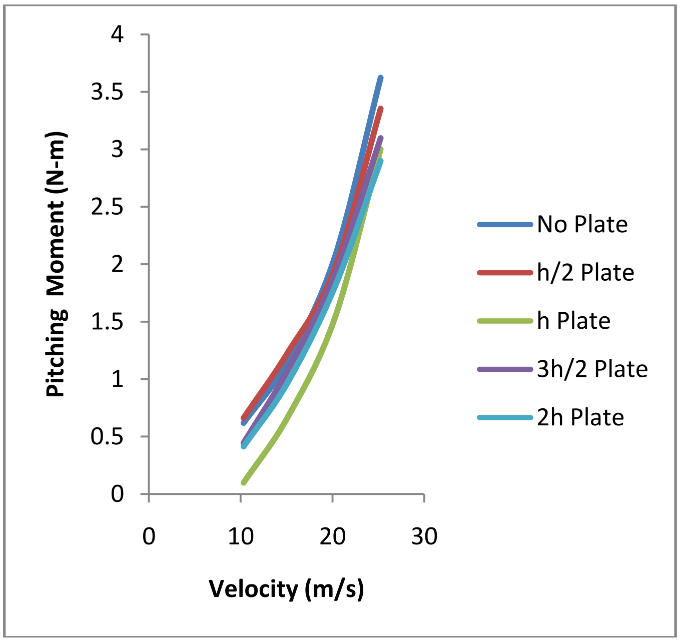

Fig. 7 Variation of Pitching Moment With Velocity in Forward Position.

From Fig.7 the plot shows the variation of pitching moment over the surface of model in the direction of flow at different velocities 10.31 m/s, 15.09 m/s, 20.25 m/s, 25.25 m/s velocities. The plot shows that the pitching moment is increasing with the increase of velocity.

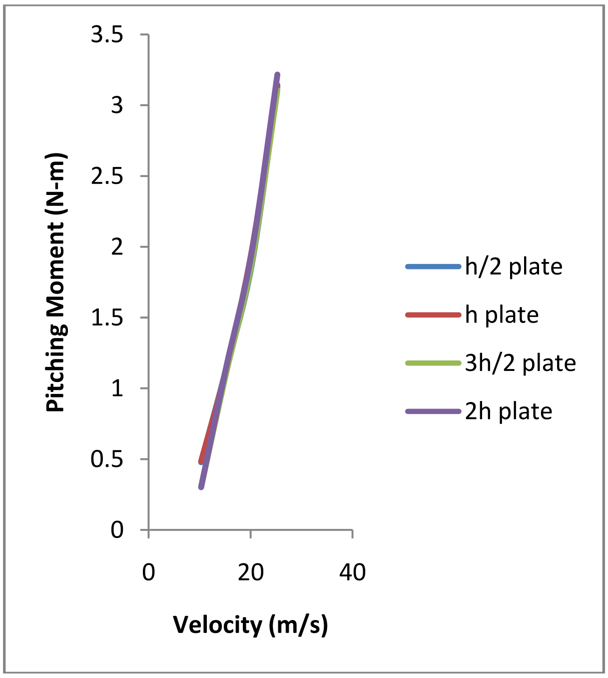

Fig.8 Variation of Pitching Moment With Velocity in Backward Position.

From Fig.8 the plot shows the variation of pitching moment over the surface of model in the direction of flow at different velocities 10.31 m/s, 15.09 m/s, 20.25 m/s, 25.25 m/s velocities. The plot shows that the pitching moment is increasing with the increase of velocity.

The variation of C_D with h is given in Fig.3 and 4.It is seen that for plate l=93mm is having less coefficient of drag when compared to other plates both in forward and backward position.

From figs.3-8 it is evident that C_D depends on the velocity. For the present bluff body without a splitter plate, C_D changes from 0.2-0.1 when the velocity changes from 10.31m/s to 25.25m/s. From the above figures we can say that forward splitter plate is more efficient when compared to the backward splitter plate because forward splitter plate gives less coefficient of drag than the backward splitter plate.

IV. CONCLUSION

- The results obtained from an experimental investigation suggested that drag coefficient gets reduced using splitter plates.
- Splitter plate with length equals to 3/2 times of height exhibits reduction in coefficient of drag for a bluff body in comparison with lengths of half of heights to twice of heights respectively.
- The splitter plate acts most efficient when the pitch angle is zero.
- Thus, performance of splitter plate with l = 3h/2 can be recommended in the application of aerodynamic add on device for automobiles.
- It increases the speed of automobile and reduces fuel consumption.

V. FUTURE WORK

The same procedure can be followed further after doing some modifications with the rectangle cylinder with splitter plate is used as aerodynamic add on device for automobiles at front portion of the car model to reduce the coefficient of drag and to improve the efficiency and speed of the vehicle.

ACKNOWLEDGEMENT

We are grateful for the research grants from the Lakkireddy Bali Reddy college of Engineering (LBRCE), the key laboratory of Aero Space Engineering (ASE) for encouragement and support to complete this project. This project would not have been possible without the help, support and patience of head of the department of Aerospace Engineering, Dr. P. LOVARAJU garu.

REFERENCES

[1] Bao Hai-Tao et al (2012), Study of different rear windscreen Angles on passenger car characteristic, IEEE.

[2] P.N.Selvaraju et al (2015), Analysis of Drag and Lift Performance in Sedan Car Model using CFD, Journal of Chemical and Pharmaceutical Sciences.

[3] Ram Bansal et al (2013), CFD Simulation for Flow over Passenger Car Using Tail Plates for Aerodynamic Drag Reduction, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

[4] Sathish Kumar K et al (2013), Enhancement of Aerodynamic Characteristics In Automobiles, IEEE.

[5] Ye Jian et al (2013), Aerodynamic Optimization Research on External Shape for a Sedan Based on Numerical Simulation, Fourth International Conference on Digital Manufacturing & Automation.

[6] R.B.Sharma et al (2014), Drag Reduction of Passenger Car Using Add-On Devices, Hindawi Publishing Corporation

[7] Bahram Khalighi et al, Unsteady Aerodynamic Flow Investigation around a Simplified Square-Back Road Vehicle with Drag Reduction Devices

[8] Young J. Moon et.al (2005),Investigation of Flow-Induced Noise from a Forward Facing Step, Japan Society of Fluid Mechanics

[9] Durst. F, and Peireira (1993) the plane symmetric sudden-expansion flow at low Reynolds numbers, J. Fluid Mech., 248, pp. 567–581.