EFFECTS OF SPOILER ON AERODYNAMIC ANALYSIS FOR PROTON PERSONA BY EXPERIMENTAL

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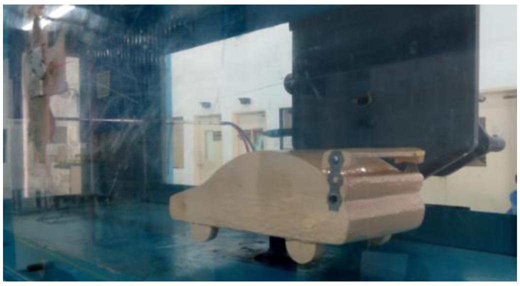
GRAPHICAL ABSTRACT



ABSTRACT

Aerodynamic analysis for automotive plays an important role in analyzing the performance of cars. The main purpose of this project is to determine the drag coefficient of Proton Persona scale car model of by the installation of spoiler at suitable height. The model car and spoiler were designed with a downscaled dimension of 1:15 using Solidwork software, and fabrication process was done using Jelutong timber (wood). Three different heights of spoiler, at 14 mm, 20 mm and 25 mm were tested at the rear end of the model car. Experiment was carried out in Subsonic Wind Tunnel for model without spoiler and with spoiler at three different heights. For both experiments, the model was tested at 5 speeds, namely at 10 m/s, 15 m/s, 20 m/s, 25 m/s and 28 m/s. Based on the result, the percentage of drag reduction was then calculated when spoiler was used. The most reduction in drag coefficient was when utilizing 20 mm spoiler height with 10.93 % drag compared with no spoiler used.

KEYWORDS

Aerodynamic; Drag Coefficient; Drag Force; Spoiler; Subsonic Wind Tunnel

INTRODUCTION

One of the important elements for cars is its aerodynamic, which affects the efficiency and performance of the car by variation of drag force at high speed. In early years, design of cars only focused on safety. However, when oil crisis occurred in 1973, which caused oil price to hike, the situation led to the improvement of car design to be more aerodynamic. Therefore, redesigning car frame and body style has changed to reducing the total weight and improving the aerodynamic criteria for fuel consumption [1]. In addition, the car can travel at higher speed with better stability and road holding.

Many researches and experiments have been conducted in the automobile industry to get the data for improving the aerodynamics of car. One of the aids that can be used to control the stability during high speed travelling is the spoiler. A spoiler affects the air flow pattern, as the air flow is spoilt as it passes over the device by converting the flow over the upper surface of car, creating down force. The performance of spoiler depends on its height. Different height will result in different drag and lift coefficient [2]. The higher the spoiler height on the car, the more effective the spoiler will be by reducing lift force; but the drag coefficient will increase as the spoiler height reaches the optimum height. However, the lift force reduces simultaneously when the drag force increases, providing stability for the car.

Drag coefficient determines the level of performance and aerodynamic ability of cars. It is a dimensionless quantity used to measure force of air resistance on an object. Therefore, in this project, the value of drag coefficient was studied to evaluate the performance of Proton Persona scale model car. Experimental studies were conducted in UTM Low Speed wind tunnel to see the effect of spoiler on the car using subsonic wind tunnel [3]. From the experiment, data of drag force was obtained and calculation was then made to determine the most effective height of spoiler to reduce drag force.

This study was conducted to determine the most suitable height of spoiler with the most reduction of drag coefficient for Proton Persona scale car model.

METHODOLOGY

The flow chart of this project is shown in figure 1 below:

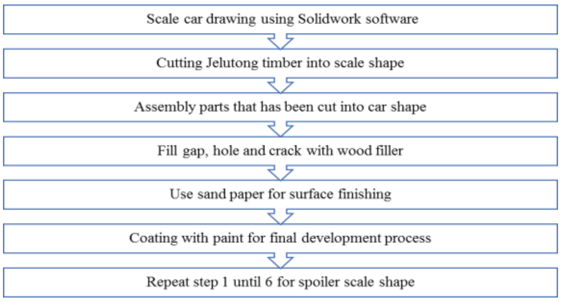
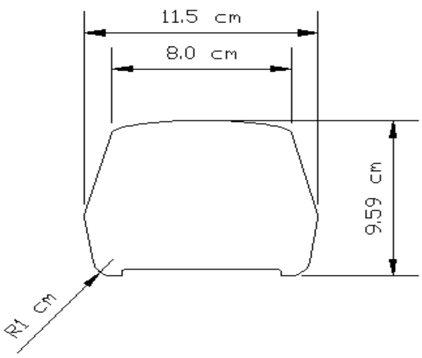
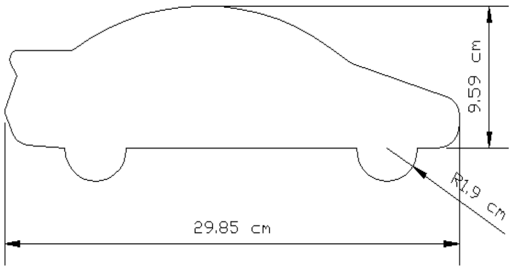


Figure 1: Process of Fabricating the Scale Model Car

The initial stage in this project involved the development, fabrication and wind tunnel model manufacturing. The scale car and spoiler were designed using Solidwork software to get the desired scale shape during fabrication. Figure 2(a) shows the front view, Figure 2(b) shows the side view dimension and Figure 3 shows the dimension of spoiler.



(a)



(b)

Figure 2: Scale Car Model Dimension

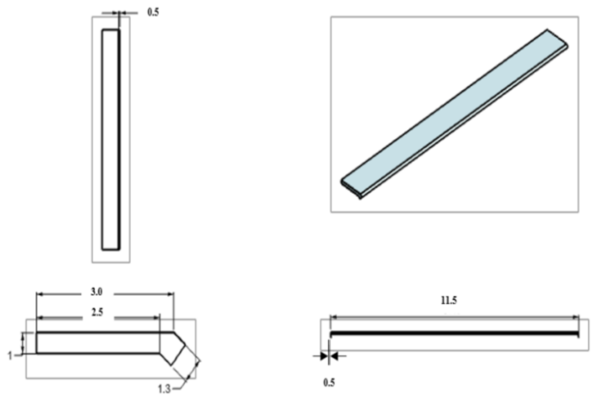


Figure 3: Dimension of Spoiler

After the model car and spoiler had been fabricated, they were tested in the Subsonic Wind Tunnel, which is a machine to run aerodynamics experiment to determine the effect of air flow around the model. There are six tools used together with the wind tunnel for conducting this experiment, which are balance, pressure gauge, data acquisition software and supporting rod. From the experiment, analysis of data will be done to get the value of drag coefficient, and graphs are plotted to see the relationship between parameters. Figure 4 shows the model installed in this study, in the test section with size of 0.45 x 0.45 meter:

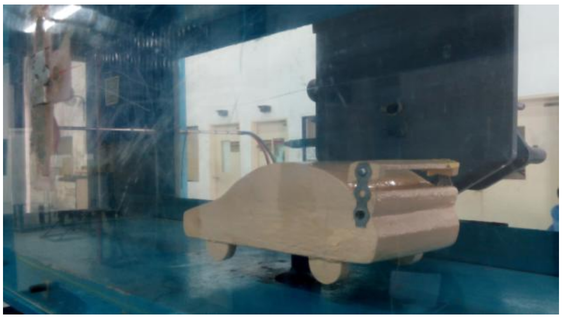


Figure 4: Model Car during Testing

Results

The results of experiment using wind tunnel for both models without spoiler and with the installation of spoiler are tabulated in the following table and figures.

Tables

The first result obtained was the model car without spoiler tested in the wind tunnel with five different speeds. Table 1 shows the experimental result of drag coefficient at corresponding wind speed for the car model. The value of drag coefficient was found reduced from 0.398 to 0.342 when the wind speed reached 28 m/s. Therefore, the average drag coefficient for this experiment was 0.366.

For the second experiment on the scale car model with three different heights of spoiler, the same experiment was done with same process and wind speed. Table 2 shows the drag coefficient value obtained for each height of spoiler. Average drag coefficient for each spoiler height is also shown.

Table 1: Results of Five Different Speeds

Speed V (m/s)	Speed^2 V^2 (m/s)	Drag Force F_D (N)	Drag Coefficient C_D	Reynolds Number Re (x 10^5)
10	100	0.248	0.398	1.76
15	225	0.520	0.371	2.64
20	400	0.904	0.363	3.52
25	625	1.376	0.354	4.40
28	784	1.669	0.342	4.93
		Average	**0.366**	

Table 2: Results of Three Different Heights of Spoiler

Speed (m/s)	Speed^2 V^2 (m/s)	Spoiler Height, h (mm)						Reynolds Number Re (x 10^5)
		14		20		25		
		Drag Force F_D (N)	Drag coefficient C_D	Drag Force F_D (N)	Drag coefficient C_D	Drag Force F_D (N)	Drag coefficient C_D	
10	100	0.227	0.365	0.217	0.349	0.231	0.371	1.76
15	225	0.478	0.341	0.459	0.329	0.508	0.363	2.64
20	400	0.834	0.335	0.805	0.323	0.894	0.359	3.52
25	625	1.293	0.332	1.234	0.317	1.389	0.357	4.40
28	784	1.592	0.326	1.524	0.312	1.723	0.353	4.93
		AVG	**0.340**	**AVG**	**0.326**	**AVG**	**0.361**	

Figures and Graphics

Four graphs were plotted based on the results obtained as in Table 1 and 2. From the graphs, drag force was found directly proportional to the speed^2 in all cases. This indicates that when wind speed in the test section of the wind tunnel was increased, the drag force also increased. Therefore, the result detected using six component balances for drag force was accepted as it showed a positive increment due to increase in speed^2.

The graph in Figure 5 was plotted according to equation:

$$F_D = \frac{1}{2}\rho V^2 A C_D \qquad (1)$$

This equation was used to validate the experiment result, where the increased squared speed would also give the effect of increasing drag force. When the speed was higher, the axial force that hit the frontal area of the scale car also would increase and result in higher drag force.

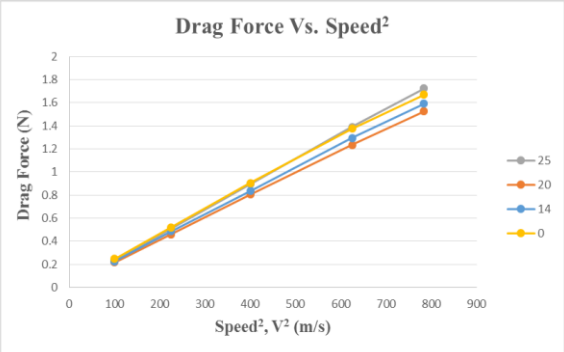


Figure 5: Graph of Drag Force vs. Speed^2

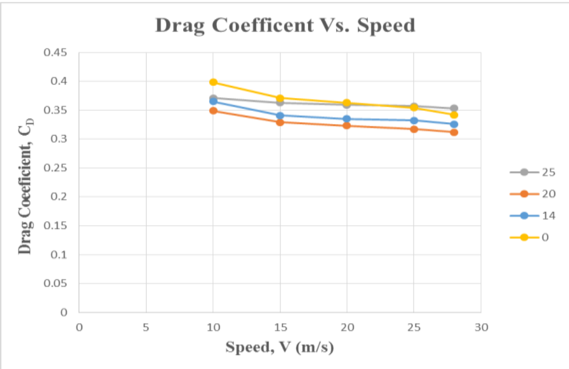


Figure 6: Graph of Drag Coefficient vs. Speed

Figure 6 shows that the value of drag coefficient decreased when speed increased. This graph proves that spoiler is an aid that helps to reduce the value of drag coefficient of the model car. For all cases, the drag coefficient reduced until reaching a constant value at the end of the speed of 28 m/s.

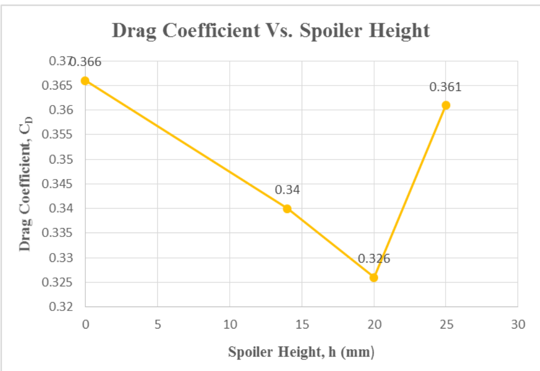


Figure 7: Graph of Drag Coefficient vs. Spoiler Height

From the experiment of both cases of model with spoiler and without spoiler, a graph as in Figure 7 was plotted to see the difference in drag coefficient value. This graph shows that when spoiler height increased, the drag coefficient decreased until it reached the optimum height at 20 mm, then the value of drag coefficient increased again at spoiler height of 25 mm.

Based on the value of drag coefficient when spoiler was used, the percentage of drag coefficient reduction was calculated. Then, comparison was made to get the most suitable height that should be used for the model. Table 3 shows the percentage of drag reduction for all spoiler heights.

Table 3: Percentage of C_D Reduction

Spoiler Height, h (mm)	% CD Reduction
14	7.10
20	10.93
25	1.37

Conclusions

As a conclusion, the value of drag coefficient for Proton Persona scale car model when spoiler is used is 0.326 at the height of 20 mm, with the total drag coefficient reduction of 10.93 %. Experiment has been carried out using wind tunnel testing for the model with three different heights of spoiler, and the results have been compared with the model without spoiler to find the height that gives the most reduction in drag coefficient value. The value of drag coefficient will increase after it reaches the optimum height.

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