UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SHAPE OPTIMIZATION OF GENERIC SIDE VIEW MIRROR

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) (Hons.)

by

ABDUL RAHMAN BIN MOHD NASIR

B071110376

891201-03-5587

FACULTY OF ENGINEERING TECHNOLOGY

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **SHAPE OPTIMIZATION OF GENERIC SIDE VIEW MIRROR**

SESI PENGAJIAN: **2014/15 Semester 2**

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DECLARATION

I hereby, declared this report entitled "Shape Optimization of Generic Side View Mirror" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) (Hons.). The member of the supervisory is as follow:

………………………………

(Project Supervisor)

ABSTRAK

Hari ini, seluruh kereta di dunia ini telah dibuat mengikut konsep aerodinamik untuk mengelakkan pelepasan gas bahaya yang tinggi dan penggunaan bahan api yang lebih rendah. Terdapat banyak bahagian-bahagian kereta yang menyumbang kepada seretan (Drag). Salah satu bahagian itu ialah cermin sisi. Walaupun cermin sisi adalah kecil, ia masih mempunyai pekali seretan (Drag Coefficient) ketika memandu pada kelajuan tinggi. Jadi, untuk mengurangkan daya seretan (Drag Force) ini, udara mengalir melalui cermin sisi mestilah kurang pergolakan. Simulasi badan kereta akan dibuat untuk mengetahui tentang bagaimana kereta boleh mengurangkan daya seretan termasuk cermin sisi. Untuk kajian ini, sasaran utama adalah untuk mengkaji aliran di sekeliling cermin sisi dan taburan tekanan. Daripada kajian terhadap beberapa jurnal, parameter yang akan memberi kesan kepada aliran dan tekanan cermin sisi (tanpa mengubah kelengkungan badan sermin sisi dan dimensi cermin sisi) adalah lebar kaki cermin sisi, ketinggian kaki cermin sisi dan sudut cermin sisi dipasang. Setakat ini, model cermin sisi yang berbeza (4 model) telah direka dengan menggunakan lukisan berbantu komputer (CAD) iaitu perisian CATIA. Kemudian, ia dianalisis menggunakan perisian komputer dinamik bendalir (CFD) yang dikenali sebagai Hyperwok. Hasil analisis dibandingkan dan dibincangkan.

ABSTRACT

Today, the entire car in this world was made according to the aerodynamic concept to prevent high danger gas emission and lower fuel consumption. There are many parts of the car that contribute to drag. One such part is the side mirrors. Although the side mirrors are small, it still has drag coefficient when driving at high speed. So, to reduce this drag force, the air flow the side mirrors must be low turbulence. In the automotive industry, the simulation of the car's body will be made to know about how good the car can reduce the drag force including the side mirror. For this research, the main targets are to study the flow around side mirror and pressure distribution. From the study in several journals, the parameters that will affect the flow and pressure of the side mirror (without changing the body curvature and dimension) are the gap (distance between the side mirror body and the attachment plate), the height of side mirror foot and the diffuser angle. So far, different side mirror models (4 models) have been designed using computer aided drawing (CAD) known as CATIA software. Then, it have been analyzed using computer fluid dynamic (CFD) software which is Hyperwork. The results of the analysis have been compared and discussed.

DEDICATION

Dedicated to my supportive father, Mr. Mohd Nasir Bin Abdullah and my beloved mother, Mdm. Hasnah Binti Lah. To my supervisor, Engr. Nur Rashid bin Mat Nuri@Md Din, lecturers, Mr. Mohd Suffian Bin Ab Razak, Mr. Muhammad Zaidan Bin Abdul Manaf, Mr. Mohd Faruq bin Abdul Latif and friends for all of their help and friendship.

ACKNOWLEDGEMENT

Alhamdulillah, thanks to Allah S.W.T for giving me life and allowed me to finish this project for Projek Sarjana Muda 1 (PSM 1). Deep in my heart, I also thanked my parents that always pray for my journey.

A lot of thanks to my project supervisor, Engr. Nur Rashid bin Mat Nuri@Md Din for supporting me to undergo this project and also providing his guidance, assistance and encouragement throughout the whole duration of the project. Not to forget, a lecturers, Mr. Mohd Suffian Bin Ab Razak, Mr. Muhammad Zaidan Bin Abdul Manaf, Mr. Mohd Faruq bin Abdul Latif for their constant guidance and support during my thesis writing is invaluable to me and continuous direction and opinion regarding the flow of the project has an invaluable contribution to achieve the objectives of the project.

I also want to thank my father, Mr. Mohd Nasir Bin Abdullah and my beloved mother, Mdm. Hasnah Binti Lah for their continued support and encouragement in everything I do. All these years of education have been made possible by their support and love.

Last but not least, I thank everyone who involved directly and indirectly in this project. The sacrifice and commitment given towards me earning my bachelor's degree are indescribable and without them, this PSM thesis would have been impossible.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

A	-	Reference Area
CAA	-	Computational Aero Acoustics
CAD	-	Computer Aided Design
CFD	-	Computational Fluid Dynamics
deg	-	Degree
DNS	-	Direct Numerical Simulations
F_D	-	Drag Force
C_d	-	Drag Coefficient
C_l	-	Lift Coefficient
C_p	-	Coefficient of Pressure
F_D	-	Drag Force
F_l	-	Lift Force
gsm	-	Generic Side View Mirror
h	-	Hour
km	-	Kilometer
$km/_h$	-	Kilometer per Hour
LES	-	Large Eddy Simulations
m	-	Meter
$m/_s$	-	Meter per Second
mm	-	Milimeter
P_{atm}	-	Atmospheric Pressure
$P_{Dynamic}$	-	The Dynamic Pressure of Air
P_{Static}	-	Barometric Pressure at the Distance from the Vehicle
P_{Total}	-	Total Pressure
RANS	-	Reynolds-Averaged Navier-Stokes
Ref	-	Reference
s	-	Second
υ	-	Velocity of an Object

ρ	-	Density of Fluid
^{o}	-	Degree of an Angle

CHAPTER 1

INTRODUCTION

1.1 Background

Today's car industry main goal is to reduce the fuel consumption. This can be achieved by reducing the car's weight and aerodynamic drag of the car or by using an electric motor. From this statement, it is related to my project which is to know the air flow through the side mirror that effect the car's aerodynamic drag. The more aerodynamic drag, the more fuel used to move the car.

$$F_D = \frac{1}{2}\rho v^2 \, C_d \, A \tag{1.1}$$

The formula above is a drag force equation for an object moving through the fluid, where F_D is the force of the drag force, ρ is the density of fluid, v is the velocity of the object, C_d is the drag coefficient and A is the reference area.

The most important variables are the reference area (frontal area of the car) and the drag coefficient. By reducing these, the aerodynamic drag will be reduced as well low the fuel consumption rate. This project is mainly about simulation of the side mirror by using software. From the analysis that will be conducted, the pressure that hit the side mirror and air flow through the side mirror will be known, thus a conclusion will be made based on the result.

While the aerodynamic body styling of the passenger car has been upgraded with a lot of efforts, the defects caused by important accessory such as the side view mirror have been ignored. The main stream meets a side flow which has the flow direction tangent to the windshield surface near the A-pillar. And a conical vortex sheet is generated along the pillar and merges into the mainstream. Therefore, very complicate flow pattern appears by combining these flow patterns near the driver side window. Moreover, since the side mirror is mounted on the driver door near hinge, the wake flow behind this obstacle become much complicated. (D. Gillespie, 2000)

1.2 Problem Statement

The flow around the side mirror is great importance. Vibration of the side mirror should be minimal in order to prevent a consequent mirror glass vibration. Vibration leads to a blurry outlook from the mirror. Besides the vibration, water droplet that stale on the mirror glass while raining also disturb the driver to looks backward clearly . So, to prevent this problem, the pressure distribution on the mirror is great important in order to reduce water stale on the mirror. One of the most important goals in today's car industry is to reduce fuel consumption. To achieve this, the cars must be lowering their aerodynamic drag. To reduce the aerodynamic drag and eventually improves the engine mileage, streamlined body must be designed in a passenger car. (H.K. Versteeg, 2007).

Besides, accessories attached to the body skin of a car can cause the unsteady air flow. Unfortunately the mirror does not pay only the aerodynamic penalty which increases body form drag, but also causes the acoustic noise and the mirror fluctuations to the cabin crews.

1.3 Objective

The objectives of this project are:

(a) To study an airflow around the side mirror

(b) To study the effect of pressure distribution at the side mirror based on different diffuser angle.

1.4 Work Scopes

To make this project work well as expected, the side mirror must be drawn properly so that the analysis can be made successful. The scopes of this project are:

(a) Design the models using CATIA.

(b) Different variables such the inclination angle of side mirror will be studied.

(c) Hyperwork software will be used for simulation method (CFD).

(d) Pressure distribution, drag coefficient and velocity flow pattern will be measured and analyzed.

1.5 Significant of Study

The advantages of Computational Fluid Dynamics (CFD) are to save cost and time while running high cost experiments using experimental wind tunnel. There is no need to rebuild a new model, just design a model by using Computer Aided Design (CAD) and the can be analyze using CFD.

1.6 Summary

The introduction about the research study is the first chapter of this report that consists of five chapters which is introduction, literature review, methodology, result and discussion and lastly conclusion of this research study. This chapter includes abstract which has dual languages (English and Malay), background, problem statement, objectives, work scopes, significant of the study and summary of this report.

Literature review is focused on next chapter based on the study of other journals. In this chapter include of the fundamental of aerodynamics that will story about how the aerodynamics drag can affect a moving vehicles. Besides, it also includes some subtopic such as the factors that influence aerodynamic and parameters associated with the aerodynamic effect assessment. This chapter is great importance to understand about this research and also very helpful to create methodology of this project.

Methodology is described in chapter 3. It consist the procedure of this project. The procedure is presented in flow chart with potential arising issues and the preventive action plans. It is concludes the project limitations and specifications, how to design the side mirror models and analysis that will be conducted. Other than that, it will briefing about CAD and CFD processing.

The next chapter is presenting the results and discussions. The output result such as the generated data of pressure coefficient, total pressure, drag coefficient and lift coefficient are presented in graphics form for qualitative discussion. The main objectives are to study the airflow around side mirror and pressure distribution, so it will be discussed on this chapter based on the result presented.

The conclusion of this project will be presented in the final chapter. It will overcome all of the study in this project and some recommendation for improvement about this thesis.

CHAPTER 2
LITERATURE REVIEW

2.1 History of Automotive Aerodynamics Technology

Aerodynamics and vehicle technology have merged so slowly and only successful after quite a lot of tries. The cooperation with fluid mechanics in traffic technology, naval architecture, and aeronautics seems to be very fruitful. This is because the designers of ships and airplane were more experiencing in this concept. They were found the originals of nature from birds and fish. Then, they have applied their finding of natural shapes to their fields.

From the finding of the designers of ships and airplane, the automobile designers tried to borrow shapes from ships and airplanes, which must have appeared progressive to them. Soon after this concept has been applied, it seems to be wrong approach to the automobile industry. In order for the aerodynamics to make a breakthrough in the automobile, these improper needed to break away.

The first automobiles were very slow on the bad roads of those days. It looks ridiculous with it streamlined bodies. It could be accomplished very well with the traditional design of horse-drawn carriages to protecting driver and passengers from wind, mud and rain. A concise overview of the history of vehicle aerodynamics is shown in Figure 2.1.

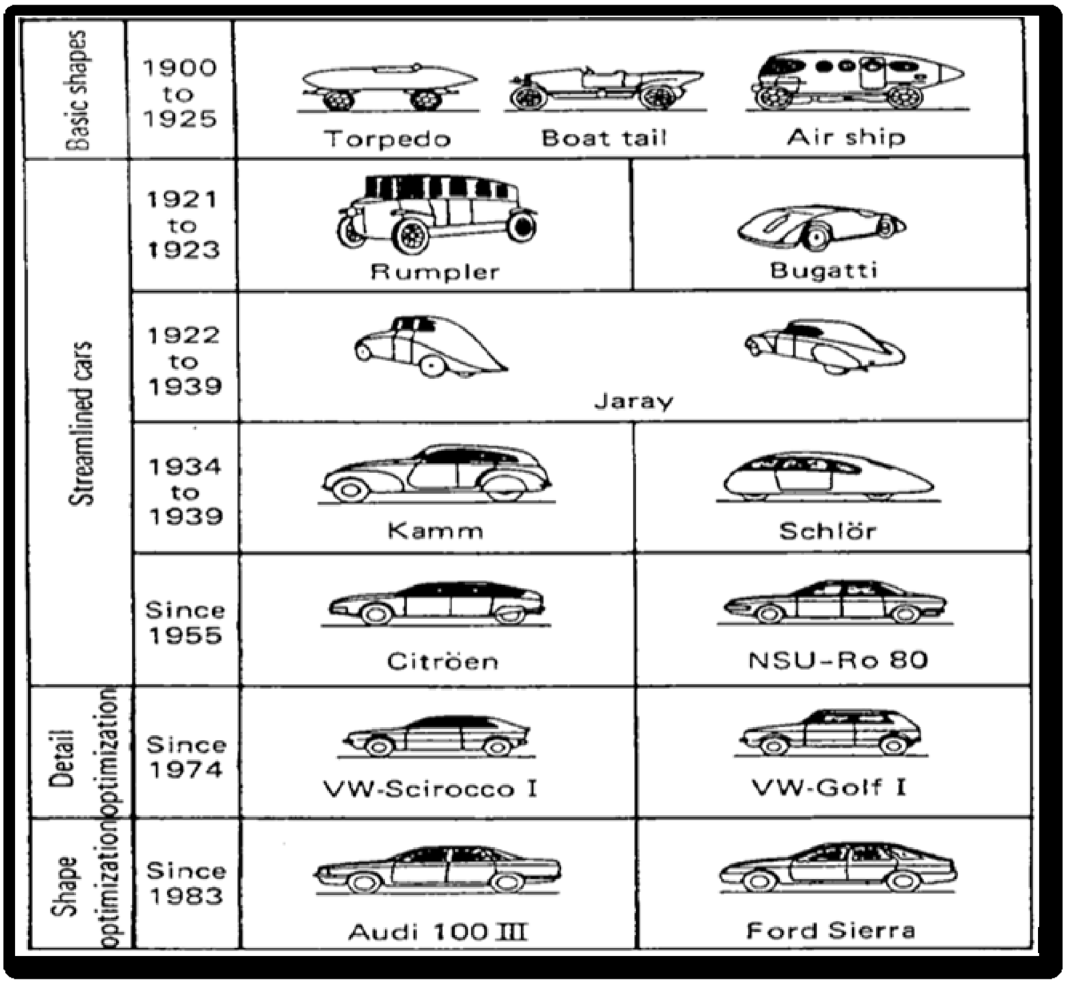

Figure 2.1: History of vehicle dynamic in passenger car Source: D. Gillespie (2000)

Aerodynamic development was done by individuals during the first two of the total four periods. Most of them were coming from the outside of car industry. They have applied basic principles of aircraft and boat aerodynamics to a car. It was later taken by the car companies and was integrated into product development. Since the companies took over, teams have been responsible for aerodynamics, not individual inventors.

The first automobile that has been made was torpedo-shaped. It was developed according to the aerodynamic principles that had given it a low drag coefficient. But the exposed driver and out of body wheels surely disturbed its good flow.

However the body was close to the ground if compare to aircrafts and underwater ships flown in a medium that encloses the body. So, it will disturb the air flow because of the ground along with the free-standing wheels and the exposed undercarriage. After several years, the studies on aerodynamic effects on cars increase and the car design developed to accommodate the increasing needs and economic reasons.

The wheels were designed inside the body that can produce a more steady flow and it also can reduce the aerodynamic drag coefficient. To maintain attached the streamline, the tail was long for many years and oddly shaped. After that, the car became advanced with smooth bodies. It also has a fenders and headlamps enclosed in the body. So, the shape from the traditional horse drawn carriages had been changed by the designers and it was a paradigm shift of automotive industry with low drag coefficient. (D. Gillespie, 2000)

2.2 Automotive Aerodynamics

Dynamics that deals with the motion of air and other gaseous fluids and with the forces acting on bodies in motion relative to such fluids is called aerodynamics. Reducing drag, reducing wind noise, minimizing noise emission and preventing undesired lift forces at high speeds are the most goals in automotive technology. In high speed, aerodynamics drag is more important to a vehicle. In the beginning of the 20th century the shape of cars was adopted from the airplane and ships inspired from bluff body analysis shown in figure 2.2. Although the cars had an aerodynamic shape but their speed was very low due to its engine and the quality of the roads.

To improve the cornering abilities for racing cars, it may also be important to produce desirable downwards aerodynamic forces (D. Gillespie, 2000). An aerodynamic automobile will be streamlined by integrate the wheel and lights in its shape to have a small surface. Crossing the wind flow above the windshield if does not have sharp edges will feature a sort of tail called a fastback or Kammback or lift back.