UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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OPTIMIZATION OF AERODYNAMIC ON SIDE VIEW MIRROR

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

by

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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 Engineering Technology (Bachelor Of Mechanical Engineering Technology (Automotive Technology) Hons.) . The member of the supervisory is as follow:

....

(Project Supervisor)

ABSTRAK

Potensi penjimatan tenaga dengan mengurangkan seretan aerodinamik kereta adalah penting dalam bidang perindustrian automotif. Sepertimana yang telah dinyatakan oleh pengkaji sebelum ini, cermin pandang sisi adalah penyumbang kepada peningkatan seretan aerodinamik sebanyak 2 hingga 7 peratus. Reka bentuk yang berbeza boleh menyumbang kepada aliran udara yang berbeza pada cermin sisi kenderaan. Ia juga boleh menyumbang kepada bunyi bising dan getaran yang menyebabkan ketidakselesaan kepada pemandu. Kajian ini dilakukan adalah untuk mengoptimumkan daya seretan aerodinamik pada cermin sisi kenderaan dengan merekabentuk semula rekabentuk asal. Beberapa parameter yang penting telah dikenal pasti untuk kajian iaitu ukuran tinggi , panjang dan lebar cermin sisi. Analisa ini dilakukan dengan menggunakan tiga model cermin sisi yang berbeza ukuran lebarnya, manakala ukuran yang lain adalah tetap. Keputusan simulasi halaju magnitut dan pemalar tekanan pada permukaan hadapan dan belakang cermin sisi. Tesis ini menerangkan penilaian kesan aliran aerodinamik pada cermin sisi kereta penumpang dengan menggunakan simulasi perisian Hyperworks Acusolve, ANSYS Fluent CFD. *Pengoptimuman reka bentuk cermin menunjukkan potensi yang besar. Semakin lebar ukuran pada model yang dikaji semakin rendah daya seretan yang dihasilkan. Parameter yang terdapat dalam kajian ini adalah pekali tekanan, jumlah tekanan, pekali seretan dan pekali daya angkat. Pekali tekanan dinilai mengikut reka bentuk cermin dan tekanan akan menyebabkan getaran permukaan cermin dan kekaburan imej. Semua keputusan simulasi di bandingkan dengan penyelidik lain.*

ABSTRACT

Potential energy savings by reducing the aerodynamic drag of the car is important in the automotive industry. As has been noted by previous researchers, side view mirrors are contributing to increase the aerodynamic drag of 2 to 7 percent. Side view mirror plays an important role in contributing drag and optimization of side mirrors are considered very important. Different design can contribute to different air flow on the vehicle side mirror. It also can cause a noise and vibration which will effect discomfort to the driver. This project is to optimize the aerodynamic drag from original design of vehicle side view mirror. Some important parameters were identified for the study such as height, length and width of the side mirrors. This analysis was performed using three different width side mirror models, while the other parameters are fixed. The simulation will concentrate on a velocity magnitude and constant pressure on the front and rear surfaces of the side view mirror. This thesis describes the assessment of the effects of aerodynamic flow toward the side mirror on the passenger car side view using Hyper Works AcuSolve simulation software, NASS Fluent CFD. Design optimization mirror shows great potential. Wider the width size of the model, the lower the drag generated. Parameters discuss in this study are the coefficient of pressure, total pressure, the coefficient of drag and lift coefficients. Pressure coefficient evaluated according to the design pressure will cause the mirror and the mirror surface vibration and blurring the image. All simulation results will compared with other researchers.

DEDICATION

Specially to my beloved parents, Hj. Mohd Yusoff bin Hj. Iskandar, Hjh Zoraida Binti Ab. Kadir, my husband Zamree Bin Harun, my two daughters Nurul Iliya Binti Zamree, Nurul Irdina Binti Zamree and my son, Muhammad Izz Irfan Bin Zamree and friends.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

2D	-	Two Dimensional
3D	-	Three Dimensional
ANSYS	-	Analysis System
CFD	-	Computational Fluid Dynamics
DNS	-	Direct Numerical Simulations
FEM	-	Finite Element Method
FYP	-	Final Year Project
RANS	-	Reynolds Averaged Navier-Stokes
ρ	-	Density
km/h	-	Kilometer per hour
m/s	-	Meter per second
m	-	Meter
V	-	Velocity
A	-	Frontal Area
L	-	Length
kg	-	Kilogram
kPa	-	Kilo Pascal
P_{static}	-	Static Pressure
$P_{dynamic}$	-	Dynamic Pressure
P_{atm}	-	Atmospheric Pressure
P_{Total}	-	Total Pressure
C_D	-	Drag Coefficient
C_L	-	Lift Coefficient
F_D	-	Drag Force
F_L	-	Lift Force
k-ε	-	K-Epsilon

CHAPTER 1
INTRODUCTION

In the automotive, industrial field has a variety of important objectives, one of which is to reduce fuel consumption, and increase safety and driving comfort. To achieve that goal is by reducing the size of the engine, an electric motor with an internal combustion engine, reduce the car's weight and improve aerodynamics on the car. There are a number of factors and car parts that contribute in drag. Side view mirrors, are also contributing in drag. This side view mirrors to increase the amount of drag by 2 to 7 percent. Mirrors play an important role in the contribution of drag and side mirrors optimization is considered very important . At 60km/h, the aerodynamic resistance is higher than the rolling views . Vehicle side mirror design also contributes to aerodynamic drag and cause noise and vibration. These factors cause discomfort to the driver. Figure 1 shows example of actual side mirror that available in the market.

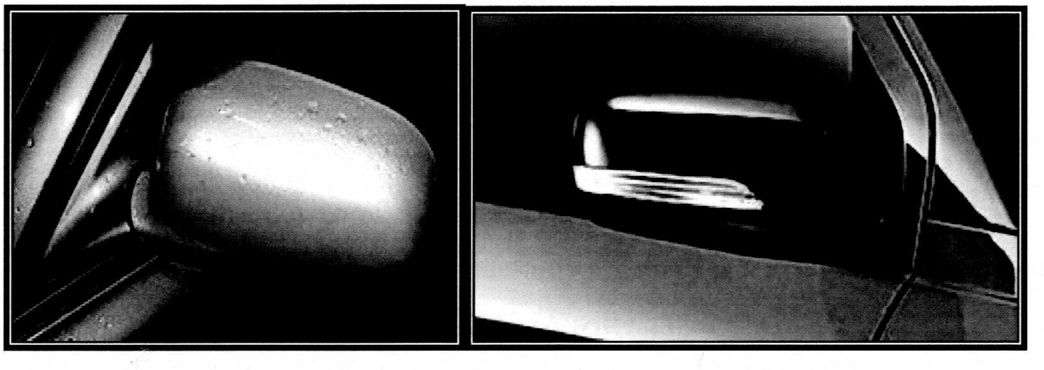


Figure 1: Example of actual side mirror that available in the market.

1.1 Problem Statement

Design of different parameter side mirror can contribute to different air flow on the side mirror of the vehicle. It can also contribute side mirror to the drag force and cause noise and vibration. Thus noise and vibration generated in the side view mirror can cause discomfort to the driver.

1.2 Project Objective

The objective of this project is redesign of the original side mirrors to reduce the coefficient of friction by using Calculated Fluid Dynamic (CFD) software. Comparing the results of the coefficient of friction was based on the original design by design.

1.3 Project Scope

The scopes of this project are:

(a) Benchmark the design of side mirror from automotive companies.
(b) Produce the detail design of a side mirror using reverse engineering methods and produce drawing using 3D CATIA software.
(c) Propose new design of side mirror with low drag coefficient.
(d) Analysis using CFD / Hyperwork software containing the aerodynamic improvements in optimization the design of the side mirror.

CHAPTER 2

LITERATURE REVIEW

2.1 SIDE VIEW MIRRORS

Side view mirrors are very important in all vehicles to facilitate an indirect vision for the driver side of the vehicle. Compliance traffic area adjacent to the vehicle that is not visible direct vision. Being able to see what is behind the car is important when reversing or changing lanes. Mirrors are often located just in front, and the front passenger door of the driver. Because of the law, today's cars have two mirrors. There are many regulations and laws when it comes to glasses, mainly due to security reasons. Mirrors today consists of more than one reflective glass. Often hold the mirror housing indicator, lighting and alarm features blind spot.

2.2 HISTORY DESIGN OF SIDE MIRROR

Design of vehicle side mirror is always changing over time. His designs have been changed based on the development and changes in automotive design. In the early development of the design of the vehicle's side mirror is a square-shaped flat and some are round and flat as shown in figure 2.1. This design was one of many components on a vehicle to be exposed to the free stream along with others such as headlights and wheel fairings. From the aerodynamic point of view, the shape of the side mirrors of vehicles are easy to understand and has been adapted to be more streamlined. However, the majority of the design of the vehicle's side mirror is exposed to flow freely while other components such as lights and wheel offerings have sunk into the bodywork to reduce drag.

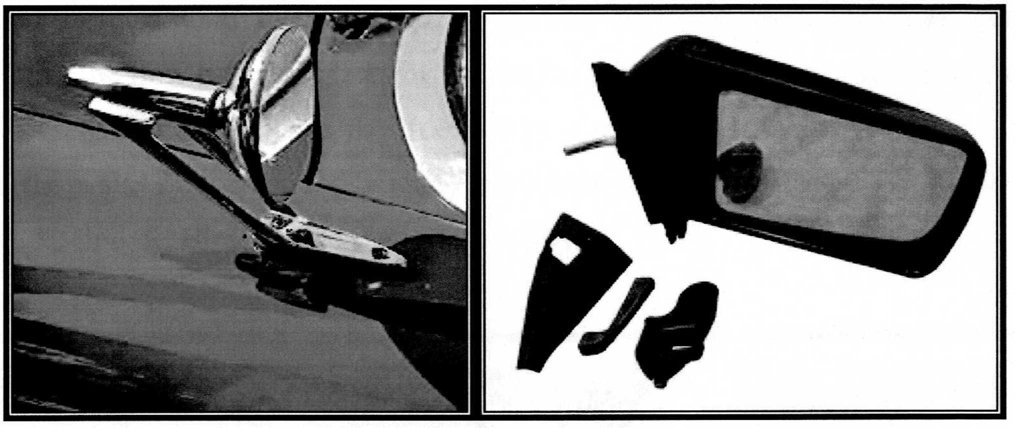


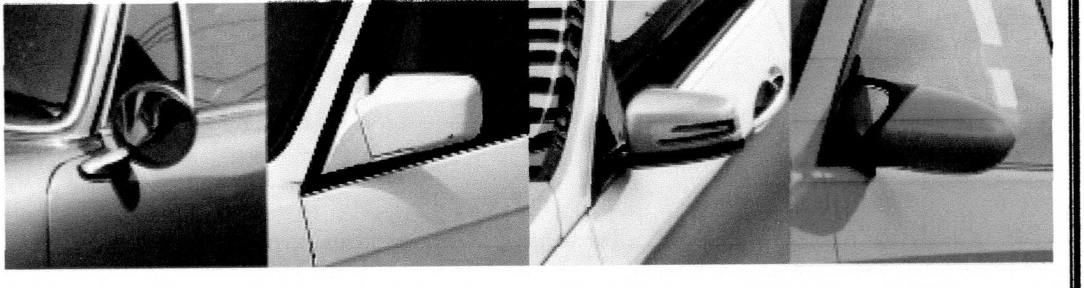
Figure 2.1: Example earliest design of side mirror

2.3 DESIGN OF SIDE MIRROR

Changes in the side view mirror design nowadays were in line with the changes during the design of passenger vehicles. The design of the side view mirrors are designed to facilitate the driver to see the rear view while driving safely. Most design esthetic is more important of good aerodynamic design. But now the aerodynamic aspects have become more important and influential automotive designs.

Designers were concerned from the point of view and a more modern design, current and relevant to the design of the vehicle. But was, however, in order to get the rear view clear and simple for the driver, the vehicle's side mirror has an impact on the improvement of aerodynamic drag is quite high and can indirectly lead to the use of fuel is increased. A part from the problem of drag, the side view mirror design also causes noise and vibration rather uncomfortable for the driver and a bit disturbing concentration while driving.

While the aerodynamic body styling of the passenger car has been concerned with considerable efforts, rather ignored have been defects caused by such accessory, the rear view mirror. 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 the 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 [W. Hucho. (1998), K. Ono, R. Himeno, T. Fukushima.(1999)].



(a) (b) (c) (d)

Figure 2.2: Different mirror designs over the years. (a) Porsche 911T since 1972, (b) BMW M3 (E30) from 1988, (c) Mercedes-Benz E-class (W212) from 2010 and (d) BMW M3 GTS (E92) from 2011.(Sources: Netcarshow.com, Asian-winds.com and arbodykits.com)

2.4 THE FLOW

The flow around the mirror is of great importance. Vibration of the mirror should be minimal in order to prevent a consequent mirror glass vibration. Vibration leads to a blurry outlook from the mirror. This flow also a□ects the aeroacoustics of the mirror. Many noises have their origin from the mirror The area where the mirror is located is a complicated area from an aerodynamic point of view. This complication comes from the a-pillar which often creates an unsteady flow and vorticities. According to Heico, the mirror increase the total amount of drag by 2-7 percent [Rajness Jaitlee.(2006)]. This means the mirrors contribute more to drag than they should in comparison to their size and the frontal area.

2.5 THE PILLAR

A pillar is an area next to the window where a large vortex shedding. When the vortex increases the value of the drag coefficient increases. Flow behavior can be attributed to the accelerated flow over a meeting of low velocity flow pillar traveling by car. Installation of the wing mirror on the side doors of the vehicle indirectly encourage vortex and differences in flow velocity in the area is high vortex and pressures, as shown in Figure 2.3.

Figure 2.3 : A Pillar Vortex shedding (www.exa.com/pages/pflow/pflow_main.html)

There is the issue say that A German consortium of automotive manufacturers Audi, Daimler, Porsche and Volkswagen have investigated the noise produced by the airflow around the A-pillars and side mirrors generic vehicle model. The model is constructed in a way that only the transmission of sound through the front side windows are related - except for very low frequencies. In fact, the front side window on the driver's side window is the only model, while the rest of the structure is nearly rigid and highly damped [18th AIAA/CAES Aero acoustic Conference (2012)]. However, vortex shedding problems can be minimized by changes made in the design of the side mirror of the vehicle.

2.6 AERODYNAMICS IN AUTOMOTIVE

Aerodynamics of cars became more and more important with the increase of their velocity. Aerodynamics is the branch of 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. Automotive aerodynamics is the study of the aerodynamics of road vehicles. The main concerns of automotive aerodynamics are reducing drag, reducing wind noise, minimizing noise emission and preventing undesired lift forces at high speeds. The frictional force of aerodynamic drag increases significantly with vehicle speed. [Tuncer Cebeci, Jian P. Shao, Fassi Kafyeke, Eric Laurendeau (2005)].

As early as the 1920s engineers began to consider the automobile shape in reducing aerodynamic drag at higher speeds. By the 1950s German and British automotive engineers systematically analyzed the effects of automotive drag for the higher performance vehicles. [Automobile Division: Institution of Mechanical Engineers, Great Britain (1957)] By the late 1960s, scientists also became aware of the significant increase in sound levels emitted by automobiles at high speed. These effects were understood to increase the intensity of sound levels for adjacent land uses at a non-linear rate. [C. Michael Hogan & Gary L. Latshaw (1973)] Soon highway engineers began to design roadways to consider the speed effects of aerodynamic drag produced sound levels, and automobile manufacturers considered the same factors in vehicle design.

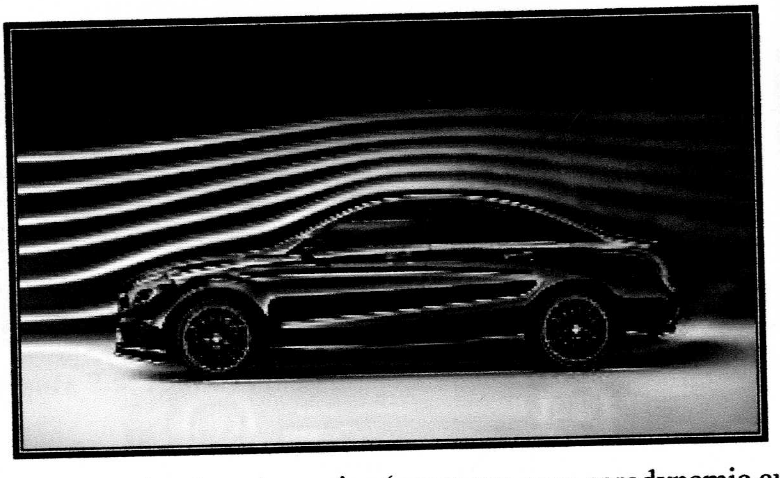


Figure 2.4: Automotive Aerodynamics (www.exa.com aerodynamic automotive)

An aerodynamic automobile will integrate the wheel and lights in its shape to have a small surface. It will be streamlined, for example, it does not have sharp edges crossing the wind stream above the windshield and will feature a set of tail called a fastback or Kammback or lift back, as shown at Figure 2.4. It will have a flat and smooth floor to support the venturi or diffuser effect and produce desirable downwards aerodynamic forces. The air that rams into the engine bay, is used for cooling, combustion, and for passengers, then accelerated by a nozzle and then ejected under the floor. Most everyday things are either caused by aerodynamic effects or in general obey the aerodynamic laws.

For aerodynamic bodies are simplifies procedure may then be devised for the evaluation of the aerodynamic loads as shown in Figure 2.5. A car driven in a road is affected by aerodynamic forces created. The aerodynamics of such cars are of vital importance. They affect the cars stability and handling. They influence both performance and safety.

Automotive mirror is a bluff body and cause significant periodic flow separation in housing, creating aerodynamic forces oscillate (due to fluctuations in the hydrodynamic pressure) above the surface of the mirror. These fluctuations cause stress not only the surface of the vibrating mirror but also produce aerodynamic noise. This joint statement is taken from the study by Mr. Nur Rashid Bin Mat Nuri @ MD Din (2010), HKVersteeg (2007).

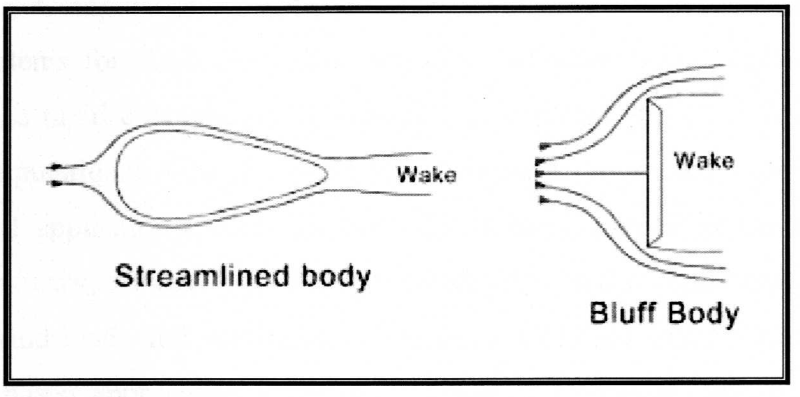


Figure 2.5: Aerodynamic of bluff bodies (HKVersteeg (2007)

2.7 COMPUTATIONAL FLUID DYNAMICS (CFD)

Nowadays, Computational Fluid Dynamics (CFD) is a branch of fluid mechanics that uses numerical methods to analyze problems that involve fluid flows. Engineers apply the experiment and CFD simulation for fluid flow analysis of their problems. Experimental data are usually used to validate the CFD solution. It also is due to high demand, demand CFD simulations predict and simulate wind tunnel tests, CFD has become a very important tool and one of the effective methods to solve the problems of aerodynamics. Due to the high demand on CFD simulation to predict and simulate wind tunnel tests, the CFD software has become a very important tool and one of the effective methods to solve the problems of aerodynamics. Computational fluid dynamics (CFD) is a computer simulation that analyzes systems for fluid flows, heat transfer, and phenomena such as chemical reactions. The rapid development of computational power and CFD technique, the field of Computational Aero Acoustics (CAA) becomes more and more relevant to the industrial applications, and this method has been applied in the area of the aerospace industry, meteorology (weather prediction), and external environment of buildings (wind loads and ventilation) commonly. CFD has many advantages over experiment based approaches, such as reduction of lead times and costs of new designs, study systems under hazardous conditions, systems that are impossible to study with controlled experiments and, the unlimited level of detail of the results.

There are also problems with CFD. The physics are complex and the result from CFD is only as good as the operator and the physics embedded. With today's computer power, there is a limitation of grid fineness and the choice of solving approach (DNS, LES and turbulence model). This can result in errors, such as numerical diffusion, false diffusion and wrongly predicted flow separations. The operator must then decide if the result is significant. While presently, CFD is no substitute for experimentation, it is a very helpful and powerful tool for problem solving. Concerning Concerning the comfort of driver, more and more attention is paid to noise in the car development process. Flow induced noise, generated by