PENGESAHAN PENYELIA

" Saya akui bahawa saya telah membaca

karya ini dan pada pandangan saya karya ini

adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan

Ijazah Sarjana Muda Kejuruteraan Mekanikal (Termal- Bendalir)"

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AERODYNAMIC STUDY OF PROTON EXORA USING COMPUTATIONAL FLUID DYNAMIC (CFD) FLUENT

NUR IZRIN BTE MAHYON

Laporan ini dikemukakan sebagai

memenuhi syarat sebahagian daripada syarat penganugerahan

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MEI 2010

"I hereby to declare that this project report entitle AERODYNAMIC STUDY OF PROTON EXORA USING COMPUTATIONAL FLUID DYNAMIC (CFD) FLUENT is written by me and is own effort except the ideas and summaries which I have clarified their sources"

Signature : ....

Author : NUR IZRIN BTE MAHYON

Date : MAY 2010

To my lovely parents, lecturers and friends for understanding and everlasting supports.

ACKNOWLEDGEMENT

Greatest praise to Allah Almighty. Grateful to Him with His will, I had successfully finished in preparing this *Projek Sarjana Muda* thesis.

Several people played an important role in the accomplishing of this *Projek Sarjana Muda* (PSM) and I would like to acknowledge them here.

I owe my most sincere gratitude to Mr. Mohd Afzanizam B. Mohd. Rosli, my PSM supervisor. I would like to thank him for his guidance, support, advices and time during the course of my project.

Special thanks to FKM Thermal- Fluid department's technician, Mr Mohd. Razmi B. Razak whom are patient in giving me a lot of advice and useful tips in conducting the experiment and testing.

I warmly thank to Mr. Yehia Abdel Monem Ahmed El- Drainy from Aeronautical Department, Faculty of Mechanical Enginering, Universiti Teknologi Malaysia who helped me a lot in Computational Fluid Dynamic CFD) simulation and give me guidance and explanation on how to conduct the right testing and experiment

My deep and sincere thank to all of my friends especially Mohd Faiz B. Mat Zaid and Hilmi Safuan B. Japar for their valuable opinion and friendly help. Their extensive discussions around my work and interesting explorations have been very helpful in completing this PSM.

I wish to express my warm and loving thanks to Muhamad Faisal B. Abdullah, whose spend his almost valuable time to help me in finishing this thesis.

Last but not least, I owe my loving thanks to both of my parents, Mdm. Rosmah Bt, Abu Bakar and Mr. Mahyon B. Mohd. Kasan. Without their encouragement and understanding it would have been impossible for me to finish my PSM. My special gratitude is due to my brother and my sisters for their loving support.

ABSTRACT

The study of ground vehicle aerodynamics is quite different from that of aircraft aerodynamics. A vehicle performances and fuel economy plays an important role in the market because these factors will influence the customer’s decision in selecting and purchasing a valued vehicle. These two factors are mainly dominated by the aerodynamic characteristics of the vehicle. Proton Exora is a squareback multi purpose vehicle (MPV); one of our national cars in year 2009, produced by Perusahaan Otomobil Nasional Berhad (Proton). Therefore, the objectives of this project is to concentrate mainly in explanations of the physical principles and on the methods of simulation measurement and experimental testing on aerodynamic characteristics for determining the lift and drag of Proton Exora from its geometry. The simulation studies were conducted by using Computational Fluid Dynamics (CFD) software, FLUENT and the experimental were conducted through the wind tunnel testing by using subsonic wind tunnel. The analysis was concentrated on all the critical region of Proton Exora and the suggestion of improvements were made based on the analyses and results from the simulation and experiment. The aims of the improvement are basically to achieve lower drag and lift coefficient. Therefore, all the modifications made on the vehicle will increase the stability and reduce fuel consumption of Proton Exora.

ABSTRAK

Kajian terhadap aerodinamik kenderaan adalah berbeza daripada kajian aerodinamik pesawat. Prestasi kenderaan dan penjimatan minyak memainkan peranan yang penting dalam pemasaran sesebuah kenderaan kerana faktor-faktor ini akan mempengaruhi pengguna dalam membuat pilihan sebelum membeli sesebuah kenderaan. Kedua-dua faktor ini juga adalah penyumbang kepada ciri-ciri dan sifat aerodinamik. Model Proton Exora adalah jenis *"squareback"*, salah sebuah kenderaan kebangsaan keluaran tahun 2009, yang dihasilkan oleh Perusahaan Otomobil Nasional Berhad (PROTON). Objektif kajian ini akan tertumpu kepada kajian prinsip fizik dan kaedah simulasi serta kajian eksperimen dalam menganggar sifat aerodinamik untuk menentukan nilai pekali daya seret dan pekali daya angkat pada Proton Exora melalui keadaan rekabentuk geometrinya. Kajian simulasi dilakukan menggunakan perisian Dinamik Bendalir Berbantu Berkomputer (CFD), FLUENT dan eksperimen dijalankan melalui ujian terowong angin. Kajian ditumpukan kepada bahagian-bahagian kritikal Proton Exora dan cadangan penambahbaikan dibuat berdasarkan keputusan-keputusan daripada simulasi dan eksperimen. Tujuan penambahbaikan adalah secara amnya untuk mengurangkan pekali daya seret dan pekali daya angkat. Keseluruhan penambahbaikan yang dicadangkan terhadap kenderaan tersebut akan meningkatkan kestabilan dan mengurangkan penggunaan minyak Proton Exora.

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CHAPTER I

INTRODUCTION

1.1 HISTORY OF AERODYNAMICS

Flows of air around vehicle and through the vehicle's body are closely related. Both flow fields must be considered together. On the other hand, the flow process within the engine and transmission are not directly connected with the flows as stated before. They are not called aerodynamics but it is aerodynamic drag that is the focus of public interest in vehicle aerodynamic. Performance, fuel economy, emissions and top speed are important attributes of a vehicle because they all are influenced by drag.

A brief overview of the history of vehicle aerodynamics is summarized in Figure 1.1. Four periods are distinguished which cannot be separated from each other. During the first two of the total four periods, aerodynamics was done by the individuals, most of them coming from outside the car industry. They tried to carry over basic principles from aircraft aerodynamics to cars. Later, during the remaining two periods, the discipline of vehicle aerodynamics was taken over by the car companies and was integrated into product development. Since then, teams, not individual inventors have been (and are) responsible for aerodynamics.

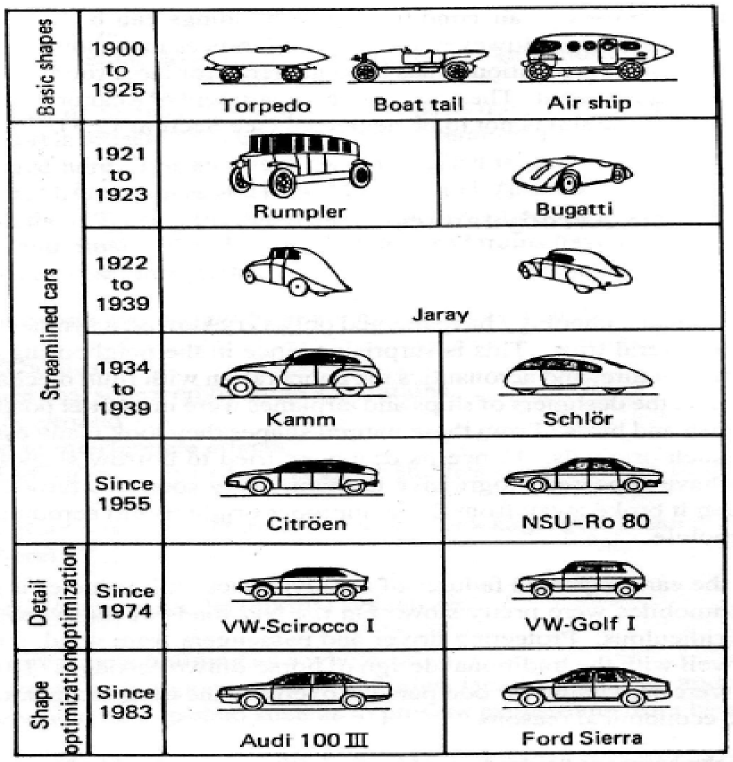

Figure 1.1: History of Aerodynamic

(Source: Hucho *et al*., 1998)

Initially, the foremost motivation for reducing the aerodynamic drag was to improve its maximum speed. Even today, in some countries top speed is a strong sales argument, despite the fact that car manufacturers no longer use it (officially). Of course, wherever speed limits were introduced this capability lost its meaning. However, low aerodynamic drag is good for more than fast driving. Drastically increasing fuel prices together with laws limiting emissions and fuel consumption have brought into focus its significance for other benefits and effects such as better fuel economy, lower emission and less global warming.

The energy crisis has generated strong public interest in the fuel economy of cars. In those countries, where fuel prices were high, good mileage always has been an important quality of road vehicles. However the current world energy situation has caused increased effort in all countries to improve the efficiency of ground transportation.

Over the past 20 years, a large worldwide effort has been made to improve the fuel economy of automobiles and the reduction of aerodynamic drag has been a major contributor to the progress that has been achieved. Of course, improvements in engine efficiency have also been made. However, to a large extent these have been offset by measures to reduce exhaust emissions. At the same time, effort on light construction has made it possible to reduce the mass of the body in white and of many components such as the engine, axles, etc. But this has been more than offset by measures to improve safety and comfort.

The drag plot shown in Figure 1.2 clearly display a trend; progress in reducing aerodynamic drag which was nearly spectacular over the last ten years has now become more moderate. The reason for this is not that the potential of aerodynamics has been exhausted. On the contrary, with concept cars it was shown that the aerodynamic drag can be reduced much further.

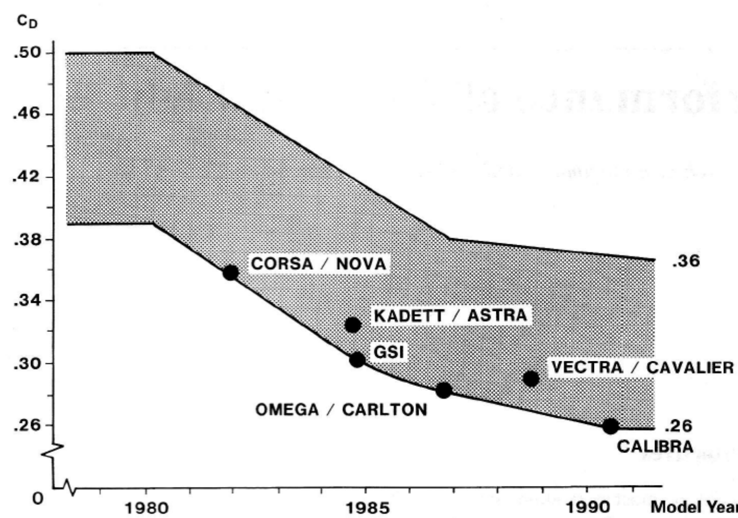

Figure 1.2: Drag Plot

(Source: Hucho *et al.*, 1998)

1.2 PROJECT OVERVIEW

The flow processes to which a moving vehicle is subjected fall into three categories; flow of air around vehicle, flow of air through the vehicle's body and flow processes within the vehicle's machinery. The first two flow fields are closely related. For example, the flow of air through the engine compartment depends on the flow field around the vehicle. Both flow fields must be considered together. On the other hand, the flow processes within the engine and transmission are not directly connected with the first two. They are not called aerodynamics, and are not treated here.

It is aerodynamic drag that is the focus of public interest in vehicle aerodynamics. It and even more so it's non dimensional number C_D, the drag coefficient has almost become a synonym for the entire discipline. Performance, fuel economy, emissions and top speed are important attributes of a vehicle; they represent decisive sales argument and they all are influenced by drag.

But vehicle aerodynamics comprises much more than drags. The flow around a vehicle is responsible for its directional stability as well: straight line stability, dynamic passive steering and response to crosswind depend on the external flow field. Furthermore, the outer flow should be tuned to prevent droplets of rain water from accumulating on windows and outside mirrors, to keep headlights free of dirt, to reduce wind noise, to prevent the windshield wipers from lifting off and to cool the engine's oil pan, muffler and brakes. The internal flow has to accommodate the heat losses of the engine. With the aid of radiator, it must ensure that this wasted heat is carried away under all driving conditions. Finally, another internal flow system has to provide a comfortable climate inside the passenger compartment.

All in all, aerodynamics has a strong influence on the design of a vehicle. However, its overall shape and its many details are primarily determined by other than aerodynamic arguments. Among these function are safety, regulations, economy and last but not least, aesthetics.

In this research, the design of Proton Exora will be analyze by performing wind tunnel testing and simulation to obtain the drag and lift coefficient. Type of wind tunnel used in this experiment is MP 130D subsonic wind tunnel (rescale), downstream fan while the simulation will use Computational Fluid Dynamic (CFD) Fluent. The model of Proton Exora will be produce using rapid prototype machine. The data obtained throughout the research will be interpreted to graphical form in order to study the patterns of the air flow around the car body and redesign the car comply with good aerodynamic features if the result of the experiment show that the value of coefficient of drag and lift is higher than the expected. Beside that, comparison of drag and lift coefficient value obtained from experiment and simulation will be made in order to determine the factors that caused the difference in both drag and lift coefficient value.

1.3 PROBLEM STATEMENT

The purpose of this study is to determine drag coefficient, C_D and lift coefficient, C_L of Proton Exora and later on to propose a new design comply with good aerodynamic features if the value of drag and lift is higher than the expected. Drag and lift has become the major interest amongst the aerodynamicist since 1970s when a group of oil exporting countries (OPEC) formed a cartel, drastically increasing the price of crude oil and simultaneously cutting production. It was readily apparent that road transport was a major factor both in terms of oil consumption and in the rising level of air pollution. Therefore, designing vehicles for low drag and hence lower fuel consumption was recognized as a matter of vital economic and environmental importance. At the time of the crisis, it was estimated that a one per cent reduction in fuel consumption would save some 310 million dollars per year in the USA. Fortunately, due to public awareness of the problem, vehicle streamlining for low drag became a positive selling point and customer resistance to the resulting unfamiliar style was lessened. Although the initial impetus was for improved fuel efficiency, it soon became apparent that there were other advantages to be obtained from good aerodynamic design such as improved roadholding and performance and reduced internal noise.

1.4 OBJECTIVE

To perform this research smoothly, several objectives are aimed in order to achieve the research goals. The objectives are:

a) To study and analyze existing aerodynamic characteristics available of Proton Exora.

b) To conduct wind tunnel testing of Exora model using subsonic wind tunnel (rescale).

c) To analyze the result from the experiment and simulation and perform comparison analysis towards each value of drag and lift coefficient obtained from experiment and simulation.

1.5 SCOPE

This research is narrowed down to certain scopes that have been identified based on the research objectives. Among the scopes that have been emphases are:

a) To conduct wind tunnel testing using MP 130D Subsonic Wind Tunnels (rescale), downstream fan that provided at FKM Fluid Lab.

b) To study and acquire lift and drag coefficient from wind tunnel experiment and CFD simulation.

c) To perform analysis on the test result by developing graphs which can be used to identified the velocity of the car.

1.6 EXPECTED RESULT

The drag and lift coefficient of Proton Exora are determined throughout this research. This research is conducted to get drag and lift force coefficient of Proton Exora and compare the results of reading between experimental and simulation method. In this research, simulation method is emphasized as a main method of the study. However, wind tunnel testing will be implemented for comparison of both drag and lift coefficient value in this research. The expectation of the drag force for Proton Exora will be not exceed 0.3 after the comparison has been made between the similar shapes with Exora.

1.7 THESIS CONTENT

This thesis entitled “Aerodynamic Study of Proton Exora using Computational Fluid Dynamic (CFD) Fluent” is divided into six chapters.

Chapter I which is the Introduction explains brief overview of history of aerodynamic and its development. The overview of the projects, objectives set for this research and the scope that been focused can be viewed in this chapter.

Chapter II is about Literature Review which includes introduction to drag and lift coefficient, type of wind tunnels and how it works, rapid prototype process that will be used in model making of Proton Exora and brief explanation of simulation software used in this study. This chapter also includes the aerodynamic design of family cars and elements of low drag design.

Chapter III explain the method used throughout the research. It started with a section describing rapid prototype machine and process followed by the type of wind tunnel used in this research also the step or procedure in implementing the wind tunnel testing. The step of CFD simulation also will be presented in this chapter.

Chapter IV presents the result and discussions obtained from the experiment done using MP 130D subsonic wind tunnel with downstream fan to perform wind tunnel testing on rescale Exora model. The chapter also includes the result data and experiment observation of the behavior of air flow around the car model.

Chapters V contains data analysis of drag and lift force and sample calculation of indicated force and actual force for both experiment. The velocity profile of the car will be interpreted into graphical forms in order to understand the air flow behavior through the car. It followed by comparison value of both drag and lift force obtained from wind tunnel testing and simulation.

The thesis is concluded in Chapter VI which explains the conclusions of the research and the relationship with problem statement presented in Chapter I.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

Aerodynamics is the study of the motion of gas (air) on an on the forces created by this motion. External and internal aerodynamics plays an important role in vehicle dynamics. The external aerodynamics study conducted focuses on estimating the effects of drag and lift. The amount of fuel and horsepower used by a vehicle are directly related to the amount of drag the vehicle experiences. Internal aerodynamics is discussed to demonstrate the techniques used to improve the cooling of the engine oil and the heat exchanger.

There are basically five different causes of aerodynamic drag on a car, each of which makes a significant contribution to the total. The primary and most important factor is the form drag. This is the resistance caused by the basic shape, derived from its proportions and its size. The kinematic viscosity of air is about one thirteenth that of water and it causes another kind of aerodynamic resistance known as surface drag. It is a kind of skin friction which increases the more the area is exposed to air stream. Adding length to the centre of a car and changing nothing else will therefore increase its surface drag and thus the total resistive forces to motion.