AN AERODYNAMIC STUDY ON MPV SPOILER

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This report is submitted in partial fulfillment
of the requirements for the award of the degree in
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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of
Bachelor of Mechanical Engineering (Automotive)"

Signature: ……………………………
Supervisor: ....
Date: ....

STUDENT'S DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : ………………………..

Author : Raguvaran a/l Jayahkudy

Date : 31st MAY 2012

Dedicated to my beloved Father and Mother

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ABSTRACT

Performance, handling, safety, and comfort of a car are significantly affected by its aerodynamic properties. Getting high power directly from the engine is just not enough to judge the performance of the car. Aerodynamic properties must be considered for the purpose of studying the drag and stability performance of a car. In order to improve a car's aerodynamic drag and its stability, an aerodynamic device is needed to perform such as the rear spoiler. Rear spoiler is an aerodynamic device that functions to 'spoil' the unfavorable air flow across the body or in the scientific explanation, to spoil the 'laminar' flow of the car's aerodynamic movement in motion. This rear placing device creates an area of high pressure to replace the usual low pressure over the trunk resulting in increasing stability of the car. Basically, rear spoilers are fitted at the trunk of a sedan car for its performance but does it gives the same results if a rear spoiler were fitted in a Multi Purpose Vehicle (MPV)? Or just for the sake of styling purpose. Thus, this report is regarding the effect of rear spoiler on a MPV and the objective of this study is to investigate the aerodynamics on a MPV vehicle with rear spoiler using CFD software (ANSYS). A simple model of the MPV had been drawn using CATiA software; import it to ANSYS software and to run the aerodynamic simulation.

ABSTRAK

Sesebuah kenderaan yang bermutu tinggi bukan sahaja dipengaruhi oleh keupayaan enjin sahaja, malah rekabentuk aerodinamik kenderaan tersebut juga amat penting. Aerodinamik sesebuah kenderaan memberi impak kepada prestasi, keselamatan, kawalan dan juga kestabilan kenderaan tersebut. Setiap kenderaan mengalami kerugian tenaga disebabkan oleh daya tujah yang bertindak kepadanya dimana daya tujahan keatas dan daya berlawanan dengan arah pergerakan kenderaan. Bagi mengurangkan tindakan daya negatif ini, "spoiler" telah dibina oleh para jurutera dan dipasang pada hampir setiap kereta di atas bonet belakang, dan amat mudah untuk dilihat pada zaman sekarang. Kebanyakan pengguna tidak tahu tujuan utama "spoiler" ini dipasang pada kenderaan malah ada yang meletakkan "spoiler" atas dasar untunk mencantikkan kenderaan mereka sahaja. Secara asasnya, "spoiler" dipasang bagi mengurangkan daya tujahan serta meningkatkan daya tekanan pada bahagian belakang kereta agar ia lebih stabil ketika memandu pada kelajuan tinggi. Ia terbukti pada kereta biasa tetapi adakah "spoiler" yang dipasang pada kenderaan jenis "Multi Purpose Vehicle" MPV mampu memberi respon yang sama atau sekadar tujuan kecantikkan 'sporty' sahaja. Tujuan projek ini adalah untuk mengkaji sejauh mana respon "spoiler" ke atas kenderaan MPV dan jikalau ya, bagaimanakah aerodinamik kenderaan MPV yang dipasang dengan "spoiler" berfungsi. Kajian CFD pada struktur kenderaan MPV ber'spoiler' dan tidak ber'spoiler' akan dikaji menggunakan perisian komputer (CATiA) dan akan disimulasi dengan menggunakan perisian komputer (ANSYS).

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

p	=	Pressure
ρ	=	Air density
v	=	Vehicle's speed
dFx	=	Net x-component of force
dFy	=	Net y-component of force
dA	=	Small element of surface area
τw	=	Wall shear stress
D	=	Drag
L	=	Lift
D_A	=	Aerodynamic drag force
C_D	=	Drag coefficient
A	=	Frontal area
L_A	=	Aerodynamic lift force
C_L	=	Lift coefficient
Tr	=	Air temperature
Pr	=	Ambient pressure
zs	=	Height of spoiler
W	=	Wingspan
H	=	Height of the wing
AoA	=	Angle of attack
Re	=	Reynolds Number

LIST OF ABBREVIATIONS

MPV	=	Multi Purpose Vehicle without spoiler
MPVs	=	Multi Purpose Vehicle with spoiler / original full specification (90degrees + 20cm length, 8cm height)
MPVss	=	Multi Purpose Vehicle with structured spoiler (100degrees + 50cm length, 8cm height)
CFD	=	Computational Fluid Dynamic
3D	=	Three Dimensional
SUV	=	Sport Utility Vehicle
F1	=	Formula one
CAD	=	Computer Aided Design
ANSYS	=	Simulation Software
Fluent	=	Simulation System/Process
CATiA	=	Computer Aided Three-dimensional Interactive Application

CHAPTER 1

INTRODUCTION

1.1 PROJECT INTRODUCTION

Nowadays, the everyday cars and even Multi Purpose Vehicle (MPV) are modified to look sportier and add some 'looks' to their ordinary vehicle by the owners for many reasons. Having tremendous amount of power from the engine leads to higher speeds for which the aerodynamics properties of the MPV given by the designer are not enough to offer the required down force and handling. The performance, handling, safety, and comfort of an automobile are significantly affected by its aerodynamic properties. Extra parts are added to the body like rear spoilers, lower front and rear bumpers, air dams and many more aerodynamics aids as to direct the airflow in different way and offer greater drag reduction to a vehicle and at the same time enhance the stability. Basically, aerodynamic styling of a vehicle is one of the most crucial aspects of vehicles design a highly complex phenomenon [1] which encompassing the task of an artful integration of advanced engineering and stylish aesthetics. A lot of emphasis is laid on the aerodynamics of a vehicle [2] design as an aerodynamically well designed vehicle spends the least power in overcoming the drag exerted by air and hence exhibits higher performance – cruises faster and longer even on less fuel consumption [3]. Apart from improved fuel economy, an aerodynamically superior vehicle offers better stability and handling at highway speeds and also minimization of harmful interactions [4] with other vehicles on the roadways.

Rear spoiler is a component to increase down force for vehicle especially passenger car. It is an aerodynamic device that design to ‘spoil’ unfavorable air movement across a car body. Main fixing location is at rear portion, depends on shape of the rear portion either the MPV’s is square back, notchback or fastback because not all rear spoiler can be fix at any type of rear portion of a MPV. Rear spoiler contributed some major aerodynamics factor which is lift and drag. The reduction of drag force can save fuel; moreover spoiler can also be used to control stability at cornering [5]. Besides that, it even functions to reduce drag and reduce rear-axle lift.

1.2 PROBLEM STATEMENT

Basically, a car spoiler is used to stabilize the performance and get a better response/control of a sedan car. Rear spoiler are fitted in the rear portion of a sedan car in order to decrease the lift and drag force acting in the car by providing down force to the vehicle so that the car gives a better response and control to the driver. Well does it give the same response if the rear spoiler were fitted on a Multi Purpose Vehicle (MPV), or act as a cosmetic purpose? Nowadays, we can see a lot of MPV were fitted with rear spoiler for sportier look and as a “wow factor” in a lame looking MPV and thus, the main task of this report is to analyze the response of a rear spoiler in a MPV. So, a case study of the spoiler’s function on a MPV needs to be analyzed in order to gain all the relevant properties using the Computational Fluid Dynamics (CFD) software (ANSYS). Besides that, how much does the spoiler effect on an MPV’s performance is also need to be taken into account.

1.3 PROJECT OBJECTIVE

This report is obliged according to the title of the project which is an aerodynamic study on MPV spoiler. Before preceding this project study, several scopes and objectives of this study have to be defined clearly and precisely. This is very essential in order to carry out this study successfully. Therefore the objectives of this study are mentioned below:-

- To study an aerodynamics on MPV vehicle with spoiler using Computational Fluid Dynamics (CFD) software.
- To analyze the aerodynamics of the MPV spoiler using CFD software.
- To design a simple MPV spoiler and to run the CFD simulation in order to observe the flow of the aerodynamics.

1.4 PROJECT SCOPE

This report is conducted on certain limitation which was listed by the supervisor as follows:-

- To study an aerodynamics on a MPV without spoiler.
- To study an aerodynamics on a MPV with spoiler.
- To differentiate both design in terms of aerodynamic flow using CFD software.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL AERODYNAMIC CONCEPT

2.1.1 Definition of Aerodynamics

Aerodynamics is a branch of Fluid Mechanics which concern on forces generated on a body in a flow and thus the aerodynamics usually involves a lot of calculation in various properties of the flow such as velocity, pressure, temperature, density and even time. In order to calculate or approximate the forces and moments acting on the bodies in the flow, we must understand the pattern of the flows [6].

2.1.2 Automotive Aerodynamics

Automotive aerodynamics is a type of study/analysis of the aerodynamic characteristic of road vehicles which involves the related properties such as reducing drag force, reducing lift force at high speed and preventing the wind noise. It is also required to produce down force in order to improve traction and cornering abilities on a road vehicle. Obviously, the shape of a vehicle does give enough response on the aerodynamics characteristic. Figure 2.1 shows the basic view of the aerodynamics of a Multi Purpose Vehicle (MPV)

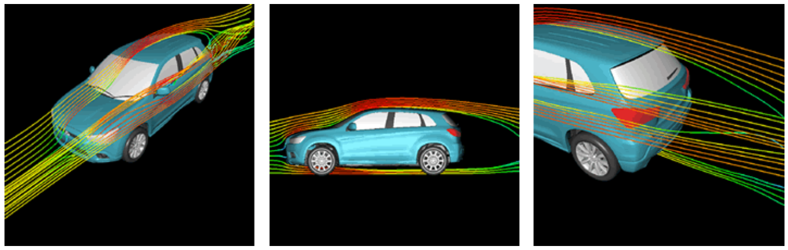

Figure 2.1: Aerodynamic flow of a MPV

2.1.3 Drag & Lift concept

There are 2 basic categories of aerodynamics forces acting on a road vehicle body which described as below and shown in Figure 2.2:-

1) Shear Stress – which acts parallel to the surface body and contributes to drag, (also known as the component of aerodynamic force parallel to the wind)
2) Pressure – which acts vertically to the surface body and contributes to lift, (also known as the component of aerodynamic force perpendicular to the wind).[7]

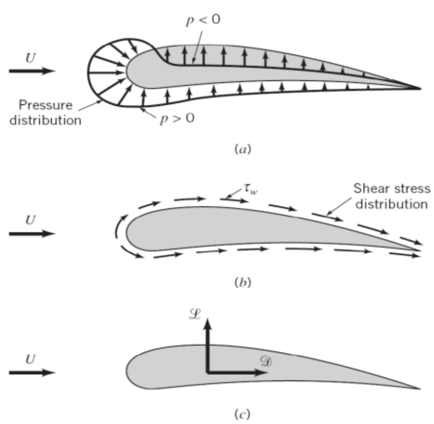

Figure 2.2: Forces acting on an Aerofoil

The resultant force of the shear stress and pressure distribution can be obtained by integrating the effects of these 2 quantities on the surface body as shown below in Figure 2.3.

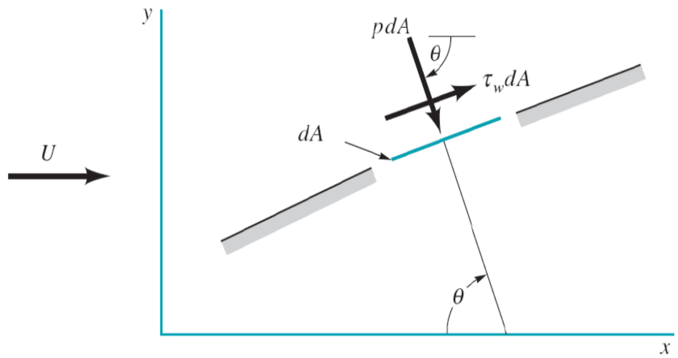

Figure 2.3: Shear force and Pressure acting on the surface body

$$dFx = (p\ dA) \cos \theta + (\tau w\ dA) \sin \theta \quad \text{[Eq. 1]}$$

$$dFy = - (p\ dA) \sin \theta + (\tau w\ dA) \cos \theta \quad \text{[Eq. 2]}$$

Thus, the net x and y component of the force on the object are:

1) Resultant force in the direction of the upstream velocity is termed the drag,D

$$D= \int dFx = \int p \cos \theta\ dA + \int \tau w \sin \theta\ dA \quad \text{[Eq. 3]}$$

2) Resultant force normal to the upstream velocity is termed of lift, L

$$L = \int dFy = - \int p \sin \theta\ dA + \int \tau w \cos \theta\ dA \quad \text{[Eq. 4]}$$

For certain three dimensional (3D) modeled bodies as in Figure 2.4, there might be also side force acting perpendicular to the plane containing Drag and Lift. The resultant force can be divided into 3 components which are moment, drag and lift coefficients but for this study, only drag and lift are to be considered.

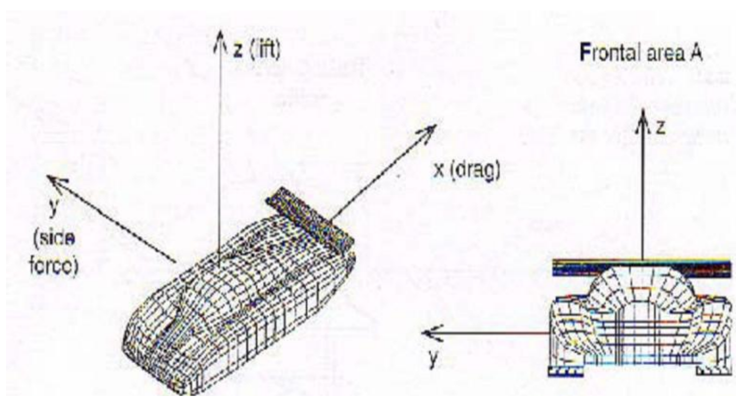

Figure 2.4: (3D) Modeled bodies

2.1.4 Drag Force

An aerodynamic drag force is the force which opposes the forward motion of the vehicle while the vehicle is in traveling mode and it acts externally on the body of the vehicle. The drag force can be measured directly by simply attaching the body subjected to fluid flow, to a calibrated spring and measuring the displacement in the flow direction. Drag force is usually an undesirable effect, like friction and mostly engineers are trying to minimize by creating many devices. Reduction of drag is closely associated with the reduction of fuel consumption in automobiles, submarines and aircraft, improved safety and durability of structures subjected to high winds and reduction of noise and vibration [8]. More sophisticated drag-measuring devices called drag balances uses flexible beams fitted with strain gauges to measure the drag electronically. Besides that, it can be calculated using formulas [Equation 5] as shown below:

$$D_A = ½ \rho v^2 C_D A \qquad \text{[Eq.5]}$$

Where; C_D = coefficient of Drag

A = frontal area (m^2)

ρ = density of air [kg/m^3]

v = velocity of vehicle [m/s]

The drag and lift forces depend on the density of the air, the upstream velocity of the wind, and the size, shape, and orientation of the body are among other elements which need to be taken into account. Therefore, it is more convenient to work with appropriate dimensionless numbers that represent the drag and lift characteristic of the body which is the drag coefficient. Modern road vehicles such as cars and MPV's have the value of coefficient of drag (C_D = 0.2 - 0.4) [9]. The smaller the value of C_D, the better the aerodynamic flow of the vehicle. In general, the more blunt the vehicle, the higher the drag coefficient as shown in Figure 2.5. As a result, the percentage of fuel