DECLARATION

I declare that this project entitled "Effect of rear spoiler inclination angle on the aerodynamic performance of hatchback model by wind tunnel" is the result of my own work except as cited in the references

Signature : ....

Name : MUHAMMAD HILMI BIN SAZALI

Date : 16th JUNE 2016

APPROVAL

I hereby declare that I have read this project report 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's Name	: ....
Date	: ....

DEDICATION

Special dedicate to my father and mother who never stop pray for me and give morale support as well as financial support. This dedication also for my supervisor who never give up to teach and guide me to complete this project and also to all technicians who always give support and help during this 2 semester of Final Year Project. Not to forget my friends who always lend a hand during this project and during period of completing the report as well as lecturers and most of all Almighty Allah who gives me good health as well as strength to go through this period. All the effort during this program will be nothing without help from all of you.

ABSTRACT

The aim of this project is to investigate the effect of strip-type and wing-type rear spoiler on inclination angle on the aerodynamic performance of hatchback model by wind tunnel and to fabricate Ahmed model with different angle of attack for strip-type and wing-type spoiler with slant angle of 35°. Scaled model of Ahmed body with 1:5 from original size and 35° of slant angle possess the blockage ratio of 0.0498 were fabricated using CubePro 3D printer along with strip-type and wing-type spoiler with different angle with the help of CATIA 3D software. Model are being tested inside MP 330D wind tunnel with maximum velocity is at 35 m/s. Lift and drag coefficient were tested on different values of Reynold's number ranging from 144×10^3 until 505×10^3 and spoiler angle of attack starting from 0 degree until 10 degree for strip-type spoiler and for wing-type until 20 degree with increment of 5 degree. This research will include the calculation for lift and drag along with Reynold's number. The result shows that as the angle of attack increase, the lift coefficient increase until 10 degree and then rise at 15 degree and go back at 20 degree. Drag coefficient shows opposite to the lift coefficient. For Reynold's number, lift coefficient value increase for 0, 5 and 20 degree but the other experience decrease as the Reynold's number increase and for drag coefficient tend to have constant value. High speed wind tunnels and use large model are recommended in order to improve the result of this research.

ABSTRAK

Tujuan projek ini adalah untuk mengkaji kesan pengacau angin belakang jenis jalur dan jenis sayap pada sudut kecondongan yang berbeza kepada prestasi aerodinamik model hatchback oleh terowong angin dan untuk mereka model Ahmed dengan sudut serangan yang berbeza untuk pengacau angin jenis jalur dan jenis sayap dengan kecondongan sudut belakang 35°. Model Ahmed yang berskala 1: 5 daripada saiz asal dan 35° sudut condong mempunyai nisbah tersumbat pada 0,0498 telah direka menggunakan pencetak CubePro 3D bersama-sama dengan pengacau angin jenis jalur dan jenis sayap dengan sudut yang berbeza dengan bantuan perisian CATIA 3D . Model diuji di dalam terowong angin MP 330D dengan halaju maksimum adalah pada 35 m/s. Pekali daya angkat dan pekali daya seret akan diuji pada nilai nombor Reynold yang berbeza yang bermula dari 144×10^3 *sehingga* 505×10^3 *dan sudut serangan pengacau angin bermula dari 0 darjah hingga 10 darjah untuk pengacau angin jenis jalur dan jenis sayap sehingga 20 darjah dengan kenaikan setiap 5 darjah. Kajian ini akan merangkumi pengiraan untuk pekali daya angkat dan pekali daya tarik bersama-sama dengan nombor Reynold. Hasilnya menunjukkan bahawa peningkatan sudut serangan, akan menyebabakan peningkatan pekali daya angkat sehingga 10 darjah dan kemudian meningkat pada 15 darjah dan kembali turun pada 20 darjah. Pekali seret menunjukkan hasil sebaliknya berbanding dengan pekali daya angkat. Untuk nombor Reynold pula, peningkatan pada nilai angkat pekali bagi 0, 5 dan 20 darjah tetapi bagi sudut yang lain mengalami penurunan sejajar dengan peningkatan bilangan Reynold dan bagi pekali seretan cenderung mempunyai nilai yang tetap. Terowong angin berkelajuan tinggi dan menggunakan model besar adalah disyorkan untuk meningkatkan hasil daripada kajian ini.*

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SUV	Sport Utility Vehicle
MPV	Multi-Purpose Vehicle
CFD	Computer Fluid Dynamic
3D	3 Dimensional
CAD	Computer Aided Drawing
ABS	Acrylonitrile Butadine Styrene
MIG	Metal Inert Gas
AoA	Angle of Attack
Cd	Drag Coefficient
Cl	Lift Coefficient
Re	Reynolds Number

LIST OF SYMBOL

mm	=	Millimeter
R	=	Radius
φ	=	Slant angle
ρ	=	Density
V	=	Velocity
C_D	=	Drag Coefficient
D	=	Total Drag
D_T	=	Operating frequency
q	=	Dynamic Pressure
S	=	Projection frontal area
F_D	=	Net drag force
T	=	Temperature
U	=	Velocity
A	=	Frontal Area
L	=	Lift force
C_L	=	Lift Coefficient
Re	=	Reynolds Number
L_C	=	Characteristics Length
μ	=	Dynamic viscosity
α	=	Angle of attack
%	=	Percent
$m/_s$	=	Meter per second
°	=	Degree
w	=	Width
h	=	Height

CHAPTER 1

INTRODUCTION

1.0 Background

The study of aerodynamics of a car has become one of the top priority for car manufacturer in order to produce optimum performance and economic fuel consumption vehicle. The air flow is differed for different shape of the vehicle segmentation such as sedan, hatchback, squareback, coupe, SUV and MPV. Hatchback car is one of the vehicle type that possess larger drag coefficient. Therefore this research will focus on this type of car.

Spoiler is an automobile parts that used to improve aerodynamic of a car by changing the flow of air or to 'spoil' the undesirable flow of air. It is also an aerodynamic device use to improve better traction and road grip while improving the aerodynamic (Wang et al., 2010). Spoiler usually fitted at the rear section of a car and can be seen on racing or sports car to increase its performance and some of them used it for styling which sometimes it could decrease the performance of the car. Performance of spoilers and wings can be analyze or measure by analytical method using Computational Fluid Dynamic (CFD) method and experimental method using wind tunnel.

Downforce is a vertical component of aerodynamics that pushed the vehicle downwards which the air flow on the upper of the car with higher pressure than the underneath of the car or spoiler. It is also known as negative lift (Zala et al., 2012). This force is importance in order to increase its performance in terms of speed and handling. This characteristic can be achieved by installing some parts on the vehicle.

Ahmed Body (Ahmed et al., 1984) are used as a bluff body which it is simple enough to manufacture and can allow the flow of air accurately but still can retain its important feature that will be experienced on vehicle bodies (Banga et al., 2015).

In this research, original Ahmed Body with dimension as Figure 1.1 has been reduce to the ratio of 1:5 from its original shape in order to get better result due to blockage effect that occur during running the experiment inside wind tunnel. Experiment also focus on study the effect of inclination angle of wing-spoiler to the drag and negative lift.

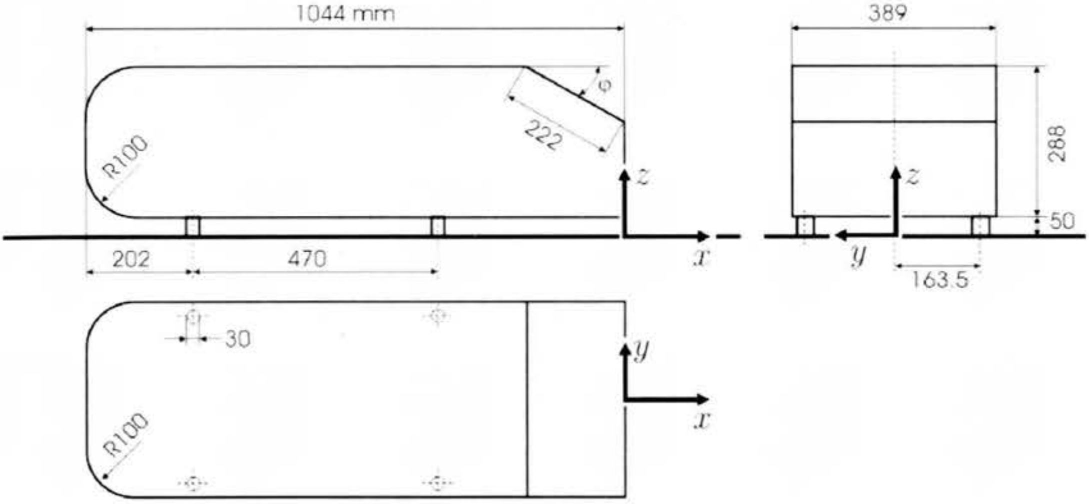

Figure 1.1: The original Ahmed body dimension in mm. (Source: Ahmed, S. R. et al, 1984)

1.2 Statement of Purpose

The purpose of the research is to investigate the effect of two different type of spoiler which strip-type spoiler and wing-type spoiler on inclination angle of spoiler on the aerodynamic performance of hatchback model by using wind tunnel.

1.3 Problem Statement

According to previous research, hatchback car model has quite large drag force compare to sedan car model (Zala et al., 2012). Besides that, there are also not many study of aerodynamics that focus on this type model especially with the instalment of the wing type rear spoiler.

1.4 Objectives

The objectives of this project are:

- To investigate the effect of strip-type and wing-type rear spoiler inclination angle on the aerodynamic performance of hatchback model by wind tunnel.
- To fabricate Ahmed model with different angle of attack for strip-type and wing-type spoiler with slant angle of 35°.

1.5 Scope of Project

The scopes of this project are:

- Ahmed model used as a testing model because its' air flow is almost the same as the real car.
- Covers only drag force and downforce experiment which affected by the inclination angle of strip-type and wing-type spoiler.
- Used subsonic wind tunnel with maximum air velocity of 35 m/s with test section of 300 mm × 300 mm × 600 mm.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, there are many important information that need to be understand by referring to various reliable sources such as internet, references book, journal and thesis. This chapter is very important in order to obtain the reliable information or data that need to be use during conducting a research work so that the research progress can be improved. In this research, all information that are needed are focused on the aerodynamic of the vehicle which are hatchback class and the experiment that need to be carried out in subsonic wind tunnel will be explained in methodology section. There are four subtopic will be concentrated aerodynamic of vehicle, Reynolds number effect, Ahmed body, spoiler, wind tunnel and blockage.

2.2 Aerodynamic

Aerodynamics is known as the flow or the way of air moves around objects (Shamsuddin, 2009). It is related to the fluid dynamics as the air flow it quite the same as the flow of fluid and also related to gas dynamics which often used with gas dynamics where it is difference being with the gas (Shamsuddin, 2009). There are a few properties that need to be considered in order to study the flow field or known as motion of air include the velocity, density, pressure and also temperature. There are three (3) interacting flow field of vehicle aerodynamics which are the flow past vehicle body, the flow past vehicle component such as wheels, heat exchanger, windshield and brakes and lastly the flow in passenger compartment. The research related to the car are mainly focused on the external aerodynamics flow as it is the study of aerodynamic where the movement of air around solid object. This characteristic is very important in car design to increase its driving performance in term of handling, stability and traffic safety along with the reduction of fuel consumption and also increase comfort characteristics. The main forces of aerodynamic that acting on the object are drag and lift which in road vehicle it is considered as negative lift or downforce. The design with low value for drag and low value of lift force is desirable to obtain an optimum performance of vehicle but that characteristic almost impossible to obtain due to the recent technology. Both of these forces are related to each other as the drag force decrease the lift force eventually will increase or vice versa. To design a car or its part, the first thing that need to make sure is the drag force need to be as low as possible and the also lift force need to be reduced as much as possible where designing a racing car such as Formula 1 should focus on getting this both force at optimum level to ensure stability of the car during cornering at high speed and to accelerate.

2.2.1 External Flow

External flow of aerodynamics is the flow of a fluid around an object that is completely submerged in it which this flow frequently occur in practice, thus it will effect several physical phenomena such as drag force, lift, upward draft, noise and vibration.

2.2.2 Aerodynamic Forces

When a body is about to flow in fluid-like medium, it will experience some resistance and forces exerted on it besides the moment in various direction around the body. Often used in analysis, there are three (3) components of forces as shown in Figure 2.1 which are:

- Drag force
- Lift force
- Side force