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Date : ……..

Signature : ……..

Name of 2nd Panel : ……..

Date : ……..

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: SATCHIAANANDHAN A/L SUBRAMANIAM

Date: 16th MAY 2011

To my beloved family

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ABSTRACT

This paper presents the analysis of automotive aerodynamic study on car spoiler by experimentation and analytical method. In this study, simulation and wind tunnel approach are used as a technique to solve the modeling problem. The mathematical models are used to develop a simulation model using FLUENT 6.2 software. Based on the simulations, the results are shown in velocity at each axis and their respective drag and lift coefficient domain to demonstrate the motion of the air flow at the vehicle and also at the spoiler. The simulation will be validated with the experiment data which the experiments will be carried out in PSM 2 next sem. Based on the results, the motion of the air flow are known more clearly and at the same time the coefficients of drag and lift are obtained for each simulation model.

ABSTRAK

Kertas kerja ini membentangkan analisis pengaliran bendalir pada sayap belakang kereta dengan kaedah eksperimen dan kaedah analisis. Dalam kajian ini, pendekatan simulasi telah digunakan sebagai satu teknik untuk mempelajari pengaliran bendalir pada sayap belakang kereta. Model matematik adalah digunakan bagi menghasilkan lapan model simulasi menggunakan satu model kereta yang sama dengan mempelbagaikan jenis-jenis dayap belakang kereta menggunakan FLUENT 6.2. Berdasarkan simulasi, keputusan-keputusan yang diperolehi dipersembahkan dalam domain halaju dan domain angkali tujahan dan seretan untuk mendemonstrasikan pengailran bendalir pada badan dan juga sayap belakang kereta. Berdasarkan hasil simulasi, pembelajaran aerodinamik pada sayap belakang kereta dapat diketahui dengan lebih jelas dan sekaligus angkali untuk tujahan dan seretan dapat diperolehi untuk setiap model kenderaan simulasi.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Spoiler is an aerodynamic automotive accessory designed to improve the airflow over a vehicle for better traction and faster speed and also is an automotive aerodynamic device whose intended design function is to 'spoil' unfavorable air movement across a body of a vehicle in motion and improve stability on the road (source: www.spoilerheaven.com). A car spoiler is affixed to and sits flush with the boot rear edge and resembles a wedge with a slightly lifted lip. "Wings" look similar to car spoilers but are raised on pedestals to stand higher off the trunk.

Officially, aerodynamics is a division of fluid dynamics concerned with the study of the movement of air as the medium (source: http://en.wikipedia.org). It usually is applied to air interacting with moving objects like cars or airplanes. An aerodynamic body is more fuel efficient because a lot of the energy is required to simply overcome air drag. When a moving car creates turbulence, the work of moving the air is done by the vehicle. An aerodynamic car disturbs the air less and therefore less work is wasted in combination. That means more work is available for moving (source: http://www.fasttrackrc.com). On average, about 60% of the power required to drive highway speeds goes to overcoming air drag. A better body design translates to lower fuel costs and to a larger range for electric cars. By changing aerodynamic features like wings, spoilers and body shape, race engineers can increase stability and traction which improves both speed and safety.

Race cars and highly modified rides incorporate car spoilers to reduce drag (force acting on an object in motion through a fluid in an opposite direction to motion, produced by friction) and improve handling at high speeds to avoid skidding and unnecessary steering. A good spoiler or wing with a well adjusted deck can make the difference between losing a race or winning it, all else being equal (source: http://www.wisegeek.com). Many sport cars today come with car spoilers already installed. Even sport utility vehicles (SUVs) have car spoilers, attached above the rear window at the top of the rear door. Aftermarket car spoilers are also available for trucks, attached to the back of the cab. Car spoilers are commonly made of molded ABS plastic, molded fiberglass or resins. Some wings are made from aluminum.

There are a lot of variety of styles of car spoilers to choose from. Universal car spoilers are designed to fit a variety of models but will need to be painted. Most spoilers are easy to self-install and come with directions to install. Before installing, hold the spoiler in place to make sure it fits the body properly and looks good. Many cars, from drag racers to sports cars to monster trucks uses different types of spoilers on them. Racing cars, like the Ferrari F1 cars, have them front and back spoiler and they are probably the most scientifically advanced wheeled transportation (source: http://www.physlink.com).

Cars have spoilers to enhance their grip on the road. Normally the weight of a vehicle is the only thing that forces the tires down onto the path. For cars without spoilers, the only way to increase the grip would be to increase the weight, or to change the multipart of the tire was made out of. The only problem with increasing the weight is that it doesn't help in cornering, where it really need to grip. All that extra weight has inertia, which have to overcome to turn, so increasing the weight doesn't help at all. The way the spoiler works is like an airplane wing, but upside down. The spoiler actually generates 'down force' on the body of the car. The advantages of this can be seen very readily. Instead of having a heavy car, which is slow, or having a very light car, which can slide away easily, now have a car that sticks better the faster it goes on the road.

Car spoilers work using the same principle as airplane wings. In airplanes, the wings are angled and shaped to cause the air travelling over the wing to move faster than the air moving underneath the wing, generating lift (source: http://www.ehow.com). With car spoilers, the effect is the same, only the shape and angles are changed to instead reduce the lift created by the body of the vehicle and create down force. Down force is a vertical force directed downward, produced by airflow around an object. Down force is generated from the front wing and rear spoiler and the venturi tunnels on a ground effect car (source: http://www.metaglossary.com). Where a wing would try to "push" up, a spoiler works by negating this upwards push, effectively improving down force. Reducing lift thus increases down force and improves traction and stability at high speeds.

Every time a spoiler produces down force it also generates drag. Drag is the natural reaction of the air to resist motion through the car. Drag is bad, because it can reduce the speed of the car. So, more down force is good but too much down force will produce too much drag, which will cause the car to cruise slowly. Very high performance sports cars, like Le Mans or F1, have a ratio called the 'lift/drag' ratio. The car designers try and maximize this so that the car has just enough force to get around the corners.

1.2 Background

The introduction of the car spoiler begin in the 1960s, when NASCAR automobiles racing vehicles still looked like what people drove on the street. In 1966, the Dodge Charger had a flatter nose and a long sloping roofline(the design of the car), that seemed to make the car unbalanced and lift at higher speeds. NASCAR was given and they allowed the Dodge teams to a piece of metal about one-half to two inches high (the spoiler) to the rear trunk (source: http://www.cardata.com). This trapped air on the trunk and creates down force to stabilize the car. It did not make the Dodge a standout car, but other manufacturers did see the aerodynamic plus side of adding something to the back of the car to increase down force.

The Dodge Daytona performed late in 1969 and won 2 out of 4 big races it ap peared it. The Daytona had a high spoiler and set new records. NASCAR has set of laws as to what spoiler size and shape can be used on each track. These rules are not popular with the racers who think the cars are too loose, because of the lack of down force the spoilers provide on the race car.

In creating a suitable automotive spoiler(or also known as wing), many factors have to be taken into consideration and all the factors should be done and tested according to the procedures so that a proper spoiler can be produced with the function of the spoiler are well known before installing it to the vehicle. It is also important to ensure that all factors are done in proper way and were successfully produce good results.

1.3 Problem Statement

Aerodynamics study is one the major theory needed to analyze in order to gain proper results of a vehicle. This studies not only related for on road vehicles but also for off road vehicles too. There are some proclamation need to be known in order to gain proper aerodynamics results for a vehicles.

Firstly, is the aerodynamic coefficient (C_d) need to be known in order to calculate the drag force. Besides that, the vehicle speed and the area exposed to the air motion also need to be known too.

Moreover, the design of the body and the spoiler of the vehicle should be known and properly designed in order to gain low C_d and also minimize the lift coefficient. The lift coefficient are one of the major constant value need to be known in order to calculate the lift force for the vehicle.

In order to solve these problems, all the analysis and experiments need to be done according to the procedures and carefully. All the reading from the analysis need to be recorded and saved properly.

1.4 Objectives

The objectives of doing this research are to study the air flow at the car spoilers and to select the best spoiler design for a car in Malaysia. The study of air flow at the car is related to fluid dynamics studies. Air flow study are used in designing cars and other vehicles to make them safer by avoiding and minimizing the aerodynamic forces such as lift, side forces and more fuel efficient by minimizing the drag force exerts on them. Therefore, it is important to design and select suitable spoiler for a car in order the functions really suits for the vehicle.

1.5 Scopes

The test is done through the simulation using fluent software. FLUENT's Computational Fluid Dynamics(CFD) software products enable to create virtual flow models within computer quickly and effectively to measure, visualize and optimize a utomotive designs early in the design process. The insight and efficiency that will be gain from using FLUENT will result in better designs in shorter cycles. FLUENT meets all of the automotive CFD needs, from component level to full vehicle analyse. The exceptional array of strong and accurate models permits for the simulation of the widest possible range of automotive CFD applications in the industry, including aerodynamics and thermal management, climate control, engine modeling, exhaust after treatment, acoustics, and multiphase applications. The simulation is to choose the suitable spoiler design for car in Malaysia.

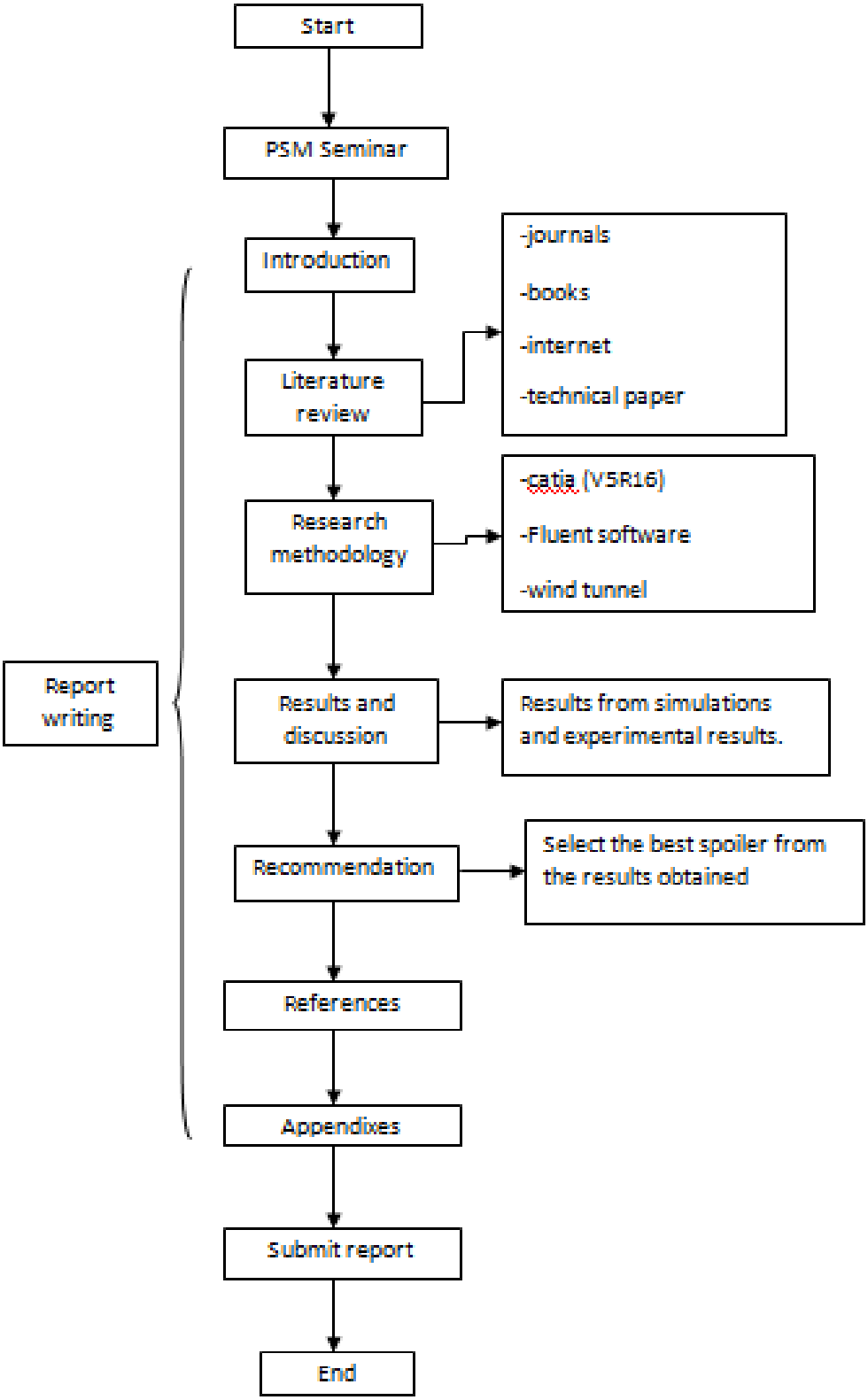
1.6 Research Contribution

It is expected that, the evaluation of car spoiler through the experiment and simulation on FLUENT will be able to fulfill the task required. Firstly the analysis (or simulation) is done using FLUENT to get the results of the air flow motion at the spoiler mainly. Then the spoiler model will be developed in order to run the experiment using subsonic wind tunnel. Hence, the comparison studies between experimental and FLUENT simulation results lead to further studies.

1.7 Outline of the Thesis

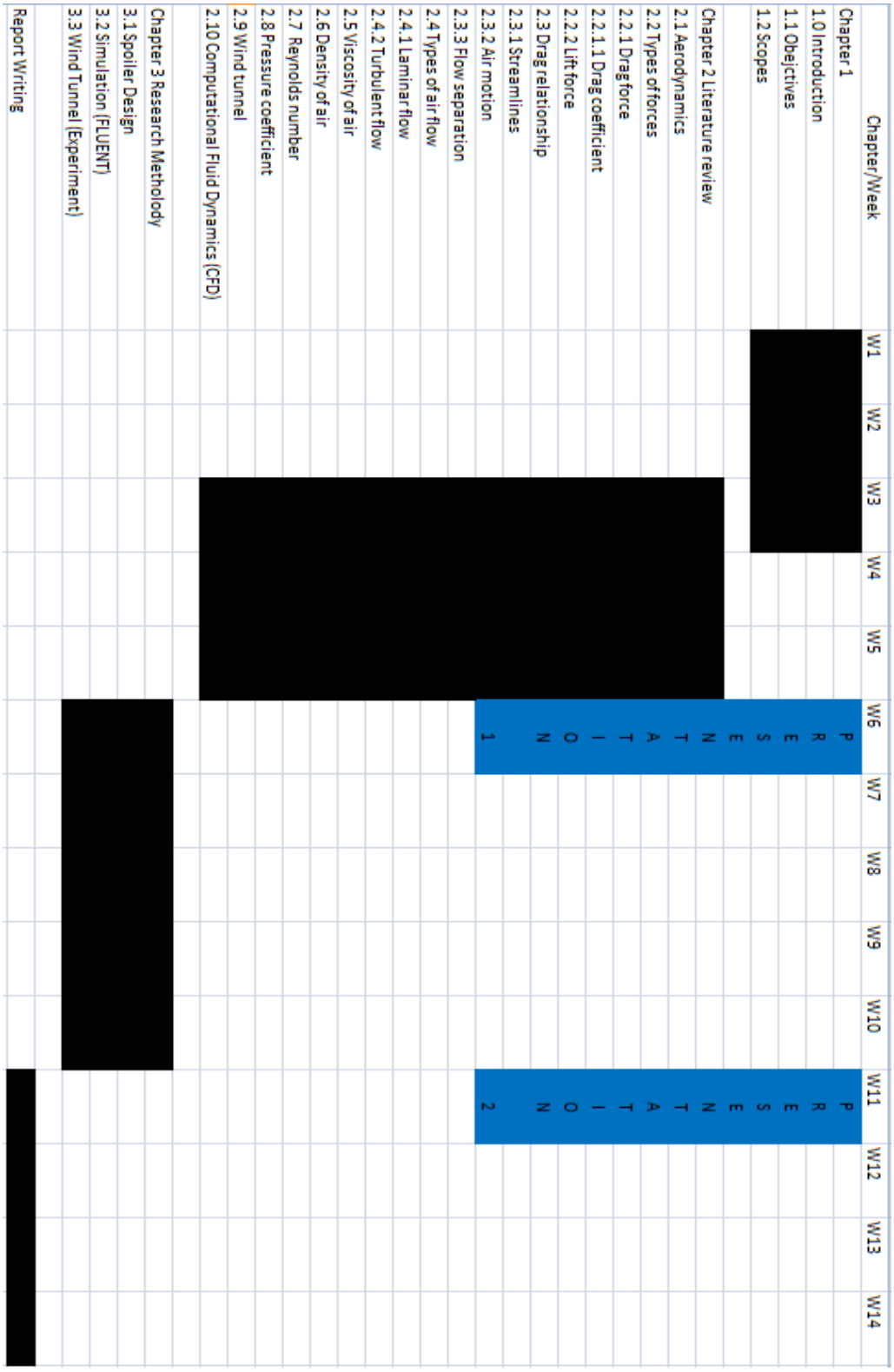
Chapter one describes about the project aim and its scope of study. In Chapter two, there is a complete literature study on aerodynamics of a vehicle. While chapter three explains thoroughly about the methods used to achieve the project objective and finally, chapter four is the result obtained from the method used. The discussion of the product and the problems encountered during the project being completed are explained in chapter five. Conclusion and recommendation for future works are explained in the final chapters.

1.8 Flow Chart

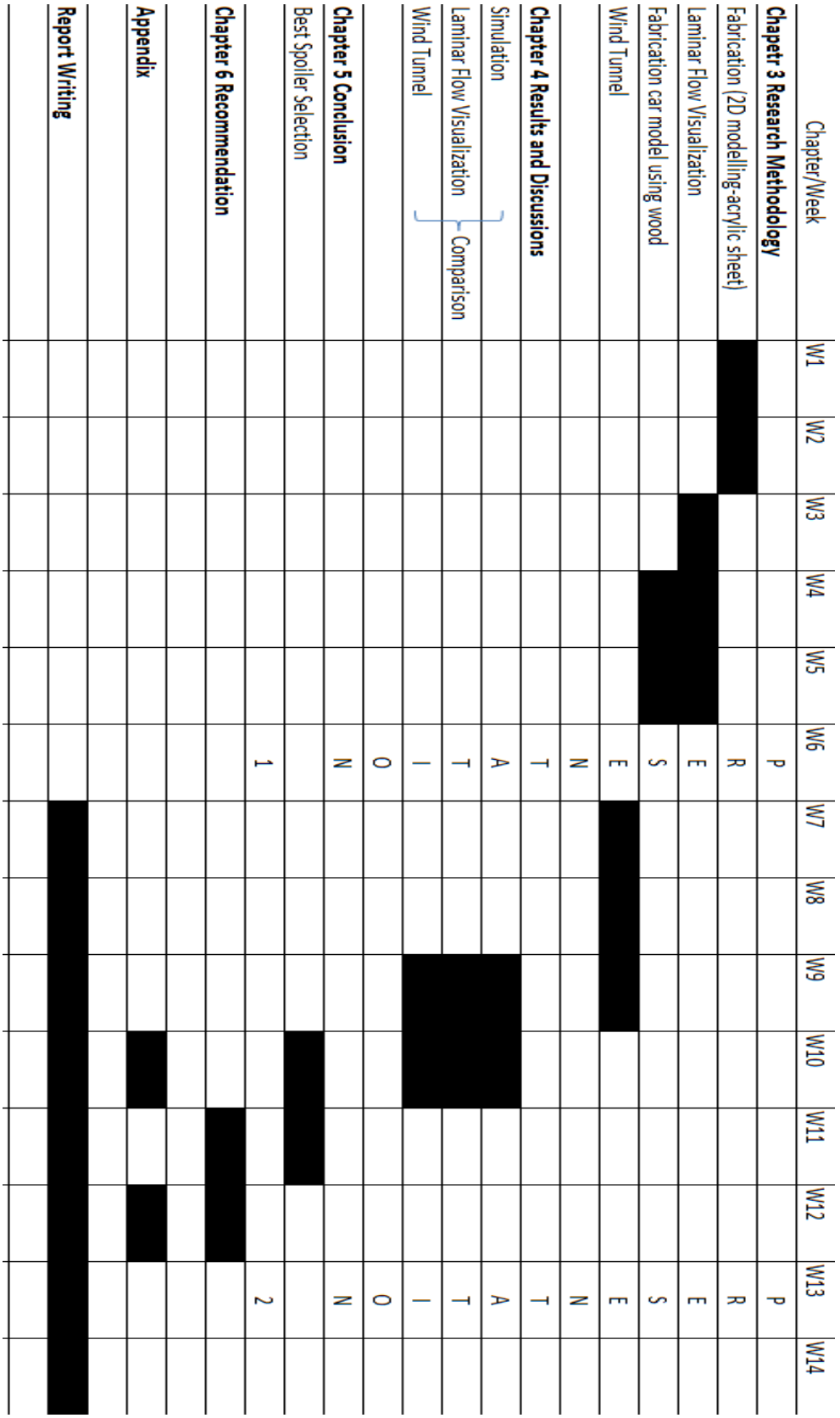


1.9 Gantt Charts of PSM

1.9.1 Gantt Chart of PSM 1



1.9.2 Gantt Chart of PSM 2



CHAPTER 2

LITERATURE REVIEW

2.1 Aerodynamics

Aerodynamics is a division of dynamics alarmed with studying the motion of air, mainly when it related with a moving object. Aerodynamics is a combinations of fluid dynamics and gas dynamics, with a lot of theory shared between them. Aerodynamics is often used very closely relating with gas dynamics, with the variation being that gas dynamics applies to all gases. Understanding the motion of air (air flow) around an object enables the calculation of forces and moments acting on the object. Typical properties calculated for a flow field includes velocity, pressure, density and temperature as a function of position and time. By signifying a control volume around the flow field, equations for the conservation of mass, momentum, and energy can be defined and used to solve the problems for the properties.

Automotive aerodynamics is the study related to the aerodynamics of on and off road vehicles. The main matters regarding of automotive aerodynamics are reducing drag, reducing wind noise, reducing noise emission, and preventing undesired lift forces and other causes of aerodynamics instability at high speeds (source: http://www.annualreviews.org). For some categories of racing vehicles, it may also be important to generate desirable downwards aerodynamic forces to improve traction and thus cornering abilities.

An aerodynamic automobile will assimilate the wheel arcs and lights in its shape to have a small surface. It will be aerodynamic, for example it does not have

sharp edges crossing the wind stream above the windshield and will point a sort of tail called a fastback or Kammback or lift back. It is important to know that the Aptera 2e and the Volkswagen 1-litre car try to decrease the area of their back. It will have a flat and smooth floor to support the venturi effect and produce wanted downwards aerodynamic forces. The air that flows into the engine bay, is used for cooling, combustion, and for passengers, and then reaccelerated by a nozzle and then driven out under the floor. For middle and rear engines, air is decelerated and pressurized in a diffuser, loses some pressure as it passes the engine bay, and fills the slipstream. These cars need a stop between the low pressure region around the wheels and the high pressure around the gearbox. Air flow which get through the wheel-bays is usually said to increase drag (German source) though race cars need it for brake cooling process and a lot of cars produce the air from the radiator into the wheel bay.

An airfoil is the shape of a wing or blade or sail as seen in cross-section. An airfoil-shaped body travels through a medium of fluid produces a force perpendicular to the motion called lift (source: http://www.makepaperairplane.com). Subsonic flight airfoils have a feature design with a rounded leading edge, followed by a sharp trailing edge, often with asymmetric camber. Foils of alike function intended with water as the working fluid are called hydrofoils.

The lift on an airfoil determines the result of its shape and its angle of attack. When either is positive, the resulting air motion field about the airfoil has a higher normal velocity on the upper surface than on the lower surface. This velocity differec e is automatically followed by a pressure difference, via Bernoulli's principle for inco mpressible zero or negligible velocity flow, which in turn produces the lift force.

2.2 Types of Forces

2.2.1 Drag Force

In fluid dynamics, drag represents to the forces that oppose the relative motion of an object through a fluid (e.g liquid) in moving motion. Drag force forms in the direction opposite to the approaching flow velocity. Different from other resistive forces such as dry friction, which is nearly independent of velocity, drag forces depend on velocity.

For a solid object moving throughout a fluid, the drag is the constituent of the net aerodynamic or hydrodynamic force acting opposite to the direction of the movement. The component perpendicular to this direction is measured as lift. Therefore drag opposes the movement of the object, and in a powered vehicle it is defeated by thrust.

The frictional force of aerodynamic drag arises significantly with vehicle speed. As early as the 1920's engineers began to think about automobile shape in reducing aerodynamicdrag at higher speeds. At 1950s German and British automotive engineers were systematically thinking out the effects of automotive drag for the higher performance vehicles (such as race cars). By the late 1960's scientists also became alert of the significant increase in sound levels produced by automobiles at high speed. These sound effects were understood to increase the intensity of sound levels for adjacent land uses at a non-linear rate. Soon highway engineers began to design roadways to think about the speed effects of aerodynamic drag produced sound levels, and automobile manufacturers carefully consider the same factors in vehicle design. Figure 2.1 shows the distribution of forces on a vehicle.

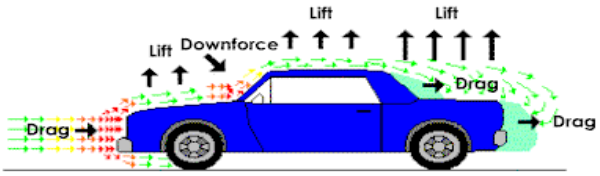


Figure 2.1: The distribution of drag forces, lift forces and down force.
(source: google.com)