AERODYNAMIC OPTIMIZATION OF F1 CAR

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'I hereby declared that I have read through this report and I found that it has comply the partial fulfillment for awarding the degree of Bachelor Mechanical Engineering (Thermal-Fluid)'

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Date :………………………….

TO MY BELOVED MOTHER

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ABSTRACT

Aerodynamics is one of the important aspects in modern racing cars. Formula One is the most dramatic examples of aerodynamics for this field. Aerodynamics factor is fundamental in racing car and must be taken into consideration in a Formula One car design. Due to that, there are studies made specifically to focus on aerodynamics optimization of F1 car. There are two main aerodynamic forces acting on a car which is drag and downforce. In a Formula One car design, aerodynamics drag is supposed to be reduced as much as possible whilst the downforce is wants to be as high as possible for a great speed racing car. This is because forces due to airflow increase with the square of the speed. To calculate the aerodynamics the fastest way than experiment is using Computational Fluid Dynamics (CFD) simulation. COSMOSFloWorks is one of the software that can be used for this simulation. In this research, the aerodynamics analyzed using COSMOSFloWorks simulation and Wind Tunnel Experiment to get data for drag coefficient, C_D and lift coefficient, C_L. A model of Formula One car is design in the research for simulation. The model is designed using SolidWorks software. Drag coefficient, C_D and lift coefficient, C_L then obtained after the model transferred to COSMOSFloWorks. Wind tunnel experiment provided value of 1.197 for C_D and -0.276 for C_L while COSMOSFloWorks simulation gave 0.5408 for C_D and -0.2033 for C_L. Comparison were made with the value for both simulation and experiment aerodynamics forces in this research.

ABSTRAK

Aerodinamik merupakan salah satu aspek penting dalam kereta lumba moden. Satu contoh yang paling dramatik dalam bidang ini adalah Formula Satu. Faktor aerodinamik adalah asas dalam kereta lumba dan mesti di ambil kira dalam pertimbangan rekabentuk kereta lumba Formula Satu. Oleh itu, banyak kajian di buat dalam pemfokusan aerodinamik kereta Formula Satu. Daya seretan, dan daya kebawah, adalah dua daya penting aerodinamik yang bertindak ke atas kereta. Dalam rekabentuk kereta Formula Satu, daya seretan sepatutnya dikurangkan sebanyak mungkin manakala daya kebawah sepatutnya adalah sebanyak mungkin untuk kereta lumba. Ini adalah kerana daya aliran udara bertambah dengan kelajuan. Pengiraan aerodinamik lebih pantas dengan menggunakan simulasi Dinamik Bendalir Berkomputer (CFD) berbanding eksperimen. Dalam kajian ini, COSMOSFloWorks adalah salah satu perisian yang digunakan untuk simulasi dan juga Ujikaji Terowong Angin. Simulasi dianalisis menggunakan COSMOSFloWorks dalam penyelidikan ini bagi mandapatkan data pekali seretan, C_D dan pekali daya kebawah, C_L. Satu model kereta Formula Satu telah direka untuk simulasi menggunakan perisian SolidWorks. Pekali seretan, C_D dan pekali daya kebawah, C_L dapat diperoleh selepas model dipindahkan ke COSMOSFloWorks. Ujikaji Terowong Angin telah memberikan nilai 1.197 untuk C_D dan -0.276 untuk C_L manakala simulasi COSMOSFloWorks memberikan nilai 0.5408 untuk C_D dan -0.2033 untuk C_L. Perbandingan di buat untuk kedua-dua ujikaji dan simulasi dalam kajian ini.

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LIST OF SYMBOL

D	=	Drag
L	=	Lift
A	=	Frontal Area
ρ	=	Air Density
V	=	Speed
km/h	=	kilometer per hour
mph	=	miles per hour
m/s	=	meter per second
kg/m^{-3}	=	kilogram per meter cube
m^2	=	meter square
N	=	Newton
C_D	=	Coefficient of Drag
C_L	=	Coefficient of Lift

ABBREVIATION

B.C	=	Before Century
CAD	=	Computer Aided Design
CAE	=	Computer Aided Engineering
CFD	=	Computational Fluid Dynamics
F1	=	Formula One
FIA	=	Fédération Internationale de l'Automobile
UK	=	United Kingdom

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CHAPTER 1

INTRODUCTION

1.1 Background Research

Aerodynamics is study of gases in motion. As the principal application of aerodynamics is the design of aircraft, air is the gas with which the science is most concerned. Although aerodynamics is primarily concerned with flight, its principles are also used in designing automobile and train bodies for minimum drag and in computing wind stresses on bridges, building, smokestacks, trees, and other structures. It is also used in charting flows of pollutants in the atmosphere and in determining frictional effects in gas ducts. The wind tunnel is one of the aerodynamicist's basic experimental tools (The Columbia Encyclopaedia, 2008). However in recent years, it has been supplanted by the simulation of aerodynamic forces during the computer-aided design of aircraft and automobiles.

One of the most important aspects of Formula One (F1) car design is aerodynamics. Creating down force, to hold the car to the ground to improve cornering; and minimising drag, which slows the car down are two primary concerns when designing the car. Modern F1 teams use expensive wind tunnels and computational fluid dynamics systems to analyse the effectiveness of an aerodynamic design for a car. In these analyses, every surface of the car, including suspension and the driver's helmet must be considered. Even an advertising sticker can affect the airflow, and placing a badge on a crucial element could produce a two-to-three percent difference in air pressure. Disrupted air flow can cause turbulence, which will produce drag to slow the car. F1 cars often have small 'winglets' before the rear wing, which 'clean up' complex air flow in order to maximise down force.

1.2 Problem Statement

The study for aerodynamics forces in a Formula One car is very important to make the car achieved great speed. This research will study the aerodynamics effect of F1 car that make the car move faster. Minimizing drag is done to improve fuel efficiency at highway speeds, where aerodynamic effects represent a substantial fraction of the energy needed to keep the car moving. The problem that will be examined in this research is to investigate the aerodynamics effect for F1 car using Computational Fluid Dynamic (CFD) software and Wind Tunnel experiment to determine the lift (downforce) coefficient, C_L and drag coefficient, C_D.

1.3 Objective

The objective for this research is as below:

i. Modelling and carry out Wind Tunnel experiment and CFD simulation of aerodynamics for F1 car.

ii. Compare and analyzed the results of drag coefficient, C_D and lift coefficient from CFD simulation and experiment.

1.4 Scope

This research scope is as stated follow:

i. F1 car model design using Solid Work.

ii. Simulation in finding the C_L and C_D by using COSMOSFloWorks.

iii. Experiment in finding the C_L and C_D by using Wind Tunnel Experiment.

CHAPTER 2

LITERATURE REVIEW

2.1 Aerodynamics Background History

Aerodynamics, literally “air in motion,” is the branch of the larger field of fluid dynamics that deals with the motion of air and other gaseous fluids. It concerns the forces that these gaseous fluids, and particularly air, exert on bodies moving through it. Without the science of aerodynamics, modern flight would be impossible. Aerodynamics (shaping of objects that affect the flow of air or gas) is a branch of fluid dynamics concerned with the study of forces generated on a body in a flow. The solution of an aerodynamic problem normally involves calculating for various properties of the flow, such as velocity, pressure, density, and temperature, as a function of space and time (thefreedictionary.com). Understanding the flow pattern makes it possible to calculate or approximate the forces and moments acting on bodies in the flow. The use of mathematical analysis, empirical approximation and wind tunnel experimentation form the scientific basis for heavier-than-air flight.

Figure 2.1: A vortex is created by the passage of an aircraft wing.

(Source: en.wikipedia.org)

The word comes from two Greek words: aerios, concerning the air, and dynamis, which means force. Aerodynamics is the study of forces and the resulting motion of objects through the air. Judging from the story of Daedalus and Icarus, humans have been interested in aerodynamics and flying for thousands of years, although flying in a heavier-than-air machine has been possible only in the last hundred years. The word "aerodynamics" itself was not officially documented until 1837. However, the observation of fluids and their effect on objects can be traced back to the Greek philosopher Aristotle in 350 B.C. Aristotle conceived the notion that air has weight and observed that a body moving through a fluid encounters resistance.

Archimedes, another Greek philosopher, also has a place in the history of aerodynamics. A hundred years later, in 250 B.C., he presented his law of floating bodies that formed a basic principle of lighter-than-air vehicles. He stated that a fluid either in a liquid or a gaseous form is continuous, basically restating Aristotle's theory of a hundred years earlier. He comprehended that every point on the surface of a body immersed in a fluid was subject to some force due to the fluid. He stated that, in a fluid, "each part is always pressed by the whole weight of the column perpendicularly above it." He observed that the pressure exerted on an object immersed in a fluid is directly proportional to its depth in the fluid. In other words, the deeper the object is in the fluid, the greater the pressure on it. Deep-sea divers, who have to accustom themselves to changes in pressure both on the way down into the sea and again on the way up to the surface, directly experience this phenomenon. (www.centennialofflight.gov)

The contributions of all of those thinkers, mathematicians, and scientists are part of the foundation of the science of aerodynamics. They paved the way for the aerodynamic developments that would occur during the nineteenth century, as well as for those who would eventually achieve heavier than air flight.

2.2 Fundamental of Aerodynamics

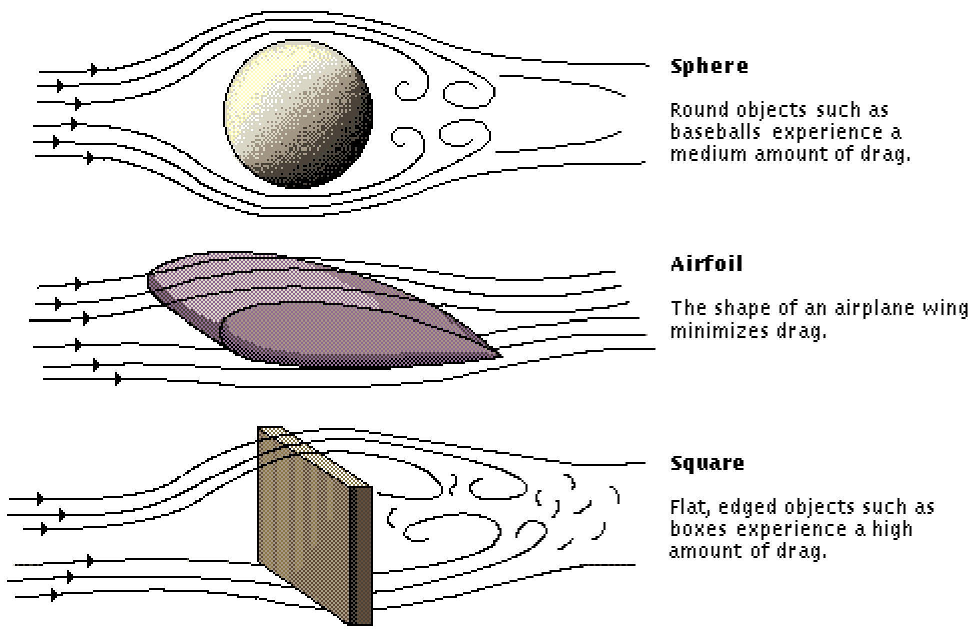

Figure 2.2: Air Flow of Aerodynamics

(Source: http://encarta.msn.com)

The shape of an object drastically affects the degree to which air resistance, or drag, impedes the object's motion. For example, a sphere, top, and especially a square, bottom, both force the air to redirect itself, slowing the objects down. An airfoil, middle, minimally disturbs the air as it travels, so the airfoil experiences little drag.