APPROVAL

‘I hereby approve have read this thesis submitted to the senate of UTeM and have accepted this thesis as partial fulfillment of the requirement for the degree in Bachelor of Mechanical Engineering (Design and Innovation) ’.

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AN AERODYNAMICS STUDY OF BODY WORK OF FORMULA STUDENT RACE CAR

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DECLARATION

"I hereby, declared this thesis entitled
'AN AERODYNAMICS STUDY OF BODY WORK OF FORMULA STUDENT RACE CAR'
is the results of my own research except as cited in the references".

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DEDICATION

To my beloved family especially my late father, Manap bin Abdullah and all my friends.

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ABSTRACT

Aerodynamics study on the bodywork of Formula Student Race Car executed in order to analyze the effect of drag force and lift force acting on the car's body shape. This study focus on analyzing and redesign of the bodywork of Formula Student UTeM in term of drag and lift force reduction. The Formula Student bodywork measured using 3D-scanner and the rest of the dimension will be measured using measuring tape. Next, the model of Formula Student UTeM modeled using SolidWorks 2008 software. In order to define the effect of drag force and lift force, two method uses this is wind tunnel method and CFD techniques. Using Fluent 6.2, CFD techniques will used to determine the aerodynamics effect on the Formula Student car shape and validated using wind tunnel result. Drag coefficient and lift coefficient observed and analyze on 1:15 scale model for both method. As result, the C_D based on CFD simulation differs as much as 2.28% while C_L differs as much as 82.62% compared to wind tunnel. Similitude technique used in order to validate CFD result at 1:1 scale model. Three new designs proposed by modification on 1:1 model and Design 1 chosen which decreased C_D as much as 0.03% and C_L as much as 0.05% compared to existing Formula Student Race Car model by using CFD technique.

ABSTRAK

Kajian aerodinamik ke atas badan kereta lumba *Formula Student* dijalankan bertujuan menganalisis kesan daya seret, dan daya angkat yang bertindak atas bentuk badan kereta. Kajian ini memberi fokus dalam mengkaji dan mereka bentuk kembali bentuk badan kereta Formula Student UTeM dalam mengurangkan kesan daya seret dan daya angkat. Badan kereta *Formula Student* UTeM pada mulanya diukur menggunakan pengimbas 3D *(3D scanner*) dan dimensi selainnya diukur menggunakan pita pengukur. Kemudian, model bentuk badan kereta *Formula Student* UTeM dilukis menggunakan perisian SolidWorks 2008. Untuk mengkaji kesan daya seret dan daya angkat, dua kaedah digunakan iaitu melalui kaedah menggunakan terowong angin dan kaedah menggunakan perisian CFD. Dengan menggunakan Fluent 6.2, CFD digunakan untuk menentukan kesan aerodinamik atas bentuk badan Formula Student dan disahkan dengan keputusan terowong angin. Pekali daya seret, dan daya angkat dikenalpasti dan dikaji ke atas model berskala 1:15 untuk kedua-dua kaedah. Sebagai keputusan, C_D mengikut simulasi CFD berbeza sebanyak 6.67% dan C_L sebanyak 82.62% berbanding kaedah menggunakan terowong angin. Kaedah persamaan digunakan untuk mengesahkan keputusan CFD pada model berskala 1:1. Tiga rekabentuk baru dicadangkan melalui pengubahsuaian pada model berskala 1:1 dan *Design 1* dipilih kerana megurangkan C_D sebanyak 0.03% dan C_L sebanyak 0.05% berbanding kereta lumba *Formula Student* asal menggunakan kaedah CFD.

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LIST OF SYMBOLS

A	=	Reference area
CAD	=	Computer Aided-Design
C_D	=	Coefficient of Drag
CFD	=	Computational Fluid Dynamics
C_L	=	Coefficient of Lift
F_D	=	Drag force
F_L	=	Lift force
FS	=	Formula Student
L	=	Characteristic length
L_M	=	Characteristic length of model (scale 1:15)
L_P	=	Characteristic length of prototype (scale 1:1)
ρ	=	Density of the fluid
ρ_M	=	Density of the fluid of model (scale 1:15)
ρ_P	=	Density of the fluid of prototype (scale 1:1)
Re	=	Reynolds Number
Re_M	=	Reynolds Number for model (scale 1:15)
Re_P	=	Reynolds Number for prototype (scale 1:1)
μ	=	Dynamics viscosity of the fluid
μ_M	=	Dynamics viscosity of the fluid for model (scale 1:15)
μ_P	=	Dynamics viscosity of the fluid for prototype (scale 1:1)
v	=	Kinematic viscosity of the object relative to the fluid
v_P	=	Kinematic viscosity of the object relative to the fluid for prototype (scale 1:1)

v_M	=	Kinematic viscosity of the object relative to the fluid for model (scale 1:15)
UTeM	=	Umiversiti Teknikal Malaysia Melaka
WYSIWYG	=	What You See Is What You Get

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Introduction

Formula Student (FS) is a student engineering competition held annually in the UK. Student teams from around the world design, build, test, and race a small-scale formula style racing car [16]. It was authorized by the Institution of Mechanical Engineers and the Society of Automotive Engineers (SAE) and applies the same rules as the original SAE. The cars are judged based on criteria include both static and dynamic events. The average speed for the competition is about 60kph (37mph) [9].

Aerodynamics is important in any type of vehicle design. The potential of aerodynamics to increase the performance of the race car is now well established [32]. The field of CFD has a broad range of applicability. The ultimate goal of the field of CFD is to understand the physical event that occurs in the flow of fluids around and within designated objects [21].

A wind tunnel is a research tool developed to assist with studying the effects of air moving over or around solid objects [10]. Wind tunnel use widely before the invention of CFD and has been the experimental method for aerodynamics study.

1.2 Problem Statement

In recent years of tournament, teams participate in Formula Student Competition improvise on their car aerodynamics. Many research conducted in order to reduce drag force acting on the car and exposed student the use of aerodynamics. Usages of wind tunnel and CFD among student have evolved the car shape and improve its aerodynamics. During this study we can simplified the problem as listed below:

- What are designs that improve aerodynamics efficiency?
- What factors that affect aerodynamics?
- What is C_D for Formula Student Race Car?

1.3 Objective of Study

1) To study existing UTeM Formula Student Race Car in term of coefficient of drag, C_D and coefficient of lift, C_L.
2) To improve existing Formula Student in term of CD and CL.
3) To design the new FS bodywork

1.4 Scope

1) Design – the design will base on UTeM current Formula Student Race Car. The design will be drawn using CAD software.
2) Analysis – Analysis will be focus on aerodynamics of the car bodywork. This includes the aerodynamics features that can be added to optimize aerodynamics effect. Analysis will be done in CFD.
3) Fabrication - A scale model will be fabricated using Rapid Prototyping. The detail drawing will be generated by CAD and scale down using Insight software which used for rapid prototyping interface.
4) Wind Tunnel Testing – Test will be run using scale model. Wind tunnel analysis then conducted.

1.5 Benefit of Study

This study will define the use of CFD and wind tunnel in determining drag force, lift force and pressure distribution. It also defines the factors which affect the aerodynamics force on the Formula Student Race Car. In outcome, UTeM Formula Student Race car will have better bodywork for their car in term of aerodynamics.

1.6 Content Outline

This section will briefly explain about this project due to its importance and boundary. In this section, we will focus on project background, objective of study, problem statement, scopes, and benefit of study.

CHAPTER II

LITERATURE REVIEW

A literature search was performed in order to study, analysis and design Formula Student Race Car. Consume resources from journals, literature books, and internet, the review has been made based on related subjects. This included the CFD techniques and Wind Tunnel Testing.

2.1 Significant of study

Singh et. (2004) stated the effect of drag on the moving vehicle is proportional to the square of velocity, so with increase in velocity (at approximately 50km/h) aerodynamics drag becomes one of the prominent factors.

Frédérique et. (2003) say that as it has been shown that 40% of the drag coefficient depends on the external shape and most of it on the rear of the geometry, a numerical optimization process is proposed here in order to seek innovative low-drag car shapes.

2.2 Formula Student

Formula Student is the biggest and best of its kind in Europe. Run by the Institution of Mechanical Engineers (IMechE), in partnership with Airbus, Autodesk, Honda Racing F1 Team, IET, Learning Grid, National Instruments, RS Components, Shell and Toyota, it promotes careers and excellence in engineering, by challenging university students to design, build, develop, market and compete as a team with a small single seater racing car [1].

2.2.1 Event

There are 5 entry classes in Formula Student, designed to allow progressive learning, which is:

Class 1 - Teams design, manufacture and race fully working cars built solely for the event, the car can not be entered into class 1 again after its first year, and instead it can be entered into class 1-200.

Class 1a - Alternative fueled class where more of an emphasis is placed on the environmental impact of racing.

Class 1-200 - The car from the previous years class 1 entry is re-entered and re-engineered to allow the students to gain experience for the class 1 event.

Class 2 - Teams that have a car that is nearly fully ready for class 1 but do not compete in the dynamic events.

Class 3 - Intial entry point into Formula Student in which teams design cars to Formula SAE rules but do not manufacture them, allowing them to get some good design feedback before they manufacture.

The cars are judged by industry specialists on the following criteria:

Static Events

- Design (150), Cost (100) & Presentation Judging (75)
- Technical & Safety Scrutinizing
- Tilt Test
- Brake & Noise Test

Dynamic Events

- Skid Pan (50)
- 1Km Sprint (150)
- 75m Acceleration (75)
- 22Km Endurance (350) & Fuel Economy (50)

2.2.2 UTeM Formula Student Race Car.

UTeM Formula Student Race Car developed by Faculty of Mechanical Engineering in order to enter Formula Varsity UTeM 2008. The competition was held on 10th August 2008, organized by Fakulti Kejuruteraan Mekanikal (FKM) and Hal Ehwal Pelajar dan Alumni (HEPA), UTeM. There are five participants for this competition which from Politeknik Sultan Salahuddin Abdul Aziz Shah, University of Nottingham, Universiti Putra Malaysia, Politeknik Kota Bharu and UTeM.

Figure 2.1: The Race Cars Lined Up at Starting Grid

The car was built by 2nd year students from Bachelor of Mechanical Engineering (automotive) with assistant of university technician and lecturer. The race built based Formula Varsity Technical Specification which provided by UTeM as organizer.