A STUDY OF AERODYNAMICS FOR F1 IN SCHOOLS

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DECLARATION

"I hereby, declared this thesis entitled
'A STUDY OF AERODYNAMICS FOR F1 IN SCHOOLS'
is the results of my own research except as cited in the references".

Signature : ....

Author's Name : MOHD FIRDAUS BIN AB RAZAK

Date : 10th May 2009

To my beloved parent and to the one who willing to seek the knowledge

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ABSTRACT

In this study, aerodynamic characteristic of the Formula One in Schools car where analyzed by using Computational Fluid Dynamic (CFD) and Wind Tunnel testing. CFD was capable to analyze the aerodynamic forces of the F1 in Schools car by obtaining drag coefficient and lift coefficient. Wind tunnel experiment was done to compare data with CFD simulation. The wind tunnel test may obtain similar aerodynamic forces from CFD. From the comparison, this study can be verified. Several models were designed and current model which was used in Wind Tunnel experiment were modified to see the differences of aerodynamic characteristic. The final design has low drag coefficient which was positive value approaching to zero and low lift coefficient which was negative value approaching to zero. The suitable drag coefficient for F1 in Schools car development is below 0.4 approaching to zero, while for lift coefficient is above -0.1 approaching zero. This study gives better understanding about the effect of aerodynamic to "F1 in Schools" cars.

ABSTRAK

Dalam kajian ini, sifat-sifat aerodinamik sebuah kereta "Formula One in Schools" dapat dikenalpasti dengan menggunakan "Dinamik Bendalir Berkomputer" (CFD) dan Ujian Terowong Angin. CFD berpotensi untuk menjalankan analisis daya aerodinamik bagi kereta "F1 in Schools" dengan mendapatkan nilai bagi pekali seretan dan pekali daya angkat. Keputusan dari eksperiment Terowong Angin turut mendapat keputusan yang sama bagi daya aerodinamik daripada analisis CFD. Daripada perbandingan ini, kajian ini dapat disahkan. Dalam kajian ini juga turut merekabentuk beberapa buah model dan model sedia ada yang digunakan di dalam eksperiment terowong angin telah diubahsuai bagi bertujuan untuk mengetahui sifat-sifat aerodinamik dan perbezaannya. Pekali seretan yang sesuai bagi merekabentuk kereta "F1 in Schools" ialah kurang daripada 0.4 dan menghampiri kosong, manakala bagi pekali angkatan ialah lebih daripada -0.1 dan menghampiri kosong. Tujuan kajian ini ialah untuk memberi penerangan mengenai sifat-sifat aerodinamik sesebuah kereta "F1 in Schools".

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LIST OF SYMBOL

A	=	Projected Area
C_d	=	Drag coefficient
C_l	=	Coefficient of lift
D	=	Drag force
D_o	=	Indicated Drag Force
l	=	Length
L	=	Lift force
L_o	=	Indicated Lift Force
ρ	=	Density
Re	=	Reynolds number
τ_{ij}	=	Stress tensor
μ	=	Dynamic viscosity
v	=	Kinematic viscosity
V	=	Velocity of fluid
x	=	Distance/length
X_A	=	Actual distance
X_S	=	Standard distance

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.0 Study Background

When the F1 in Schools' cars were launched, the speed was build up rapidly due to thrust which was caused by CO_2 pressurized cartridge. This is similar to a bullet fired from a rifle. The speed was believed to be exceeding 70km/h or 19.44m/s at the early stage of the launching. Due to aerodynamic effect, the car tends to slow down at the end of the finish line which gives different time record [5].

It is obvious that the car with better aerodynamic shape is faster than a car with blunt shape. These because of air resistance occur while the car is moving along the track. The external flow of air around the cars can be determine by wind tunnel experiment, calculation and computerized solving which is known as Computational Fluid Dynamics (CFD) [6].

From the usage of CFD, the car can be design effectively in order to achieve better aerodynamic properties like low drag and low downforce. The CAD model can be tested without the physical model or prototype. The model has to be meshed before it can proceed to CFD analysis. However, CFD analysis has quantized error due to numerical iteration and the choices of turbulence model. The CFD analysis can be verified with wind tunnel experiment and calculation [16] [21].

Wind tunnel test is performed and the actual condition of the car can be monitor. This test is quite complex and time consuming. For this study, the prototype had to be prepared by using Rapid Prototyping machine. The 3D model used in CFD may also used for Rapid Prototyping process.

From the wind tunnel result, CFD setting shall be adjusted to gain similar result from the wind tunnel. Further study of aerodynamics can be proceeding as suitable setting obtained. The aerodynamic characteristic can be determine and can gives better understanding of the design consideration of a Formula Student in Schools car.

1.2 Problem Statement

The aerodynamics study about the F1 in Schools is quite interesting because slight changes and differences may cause the performance of the car same as real F1 cars. Many of the contestants from the school within Malaysia did not have proper data and analysis to investigate the effect of the aerodynamics. Past two year, Malaysia team from SMK Convent Bukit Nanas had awarded third place, afterward, no other Malaysian team can go further [5]. These may because of improper analysis for the building of the cars.

- Mostly the student designed the cars with ecstatic element rather than aerodynamic efficiency.
- Majority of them use basic shape and with small modification for better look.

1.3 Objectives of Study

From the problem statement, the solution has been planned and the objectives for this study were set. The objectives of this project are:

- To study the effect of aerodynamics in "F1 in School" cars.
- To provide a systematic research about the aerodynamic.
- To compare the designed "F1 in School" car with the fastest car as a benchmark which was recorded in 2007 International Finals.
- To fabricate the designed car.
- To perform the wind tunnel test.
- To run CFD simulation for modeled Formula One in Schools cars.

1.4 Scope of Study

The main objectives of this research are to make analysis about the aerodynamic effect on "F1 in School" cars and then to fabricate them. This project will covers from:

- Designing: design consideration about feature in real F1 cars, specification studies given by the organizer, manufacturing considerations are taken into account, design concept and 3-dimension modeling. 3-dimension modeling of previous world record holder shall be made. The software used for 3-dimension modeling is CATIA V5R10
- CFD Analysis: Aerodynamics analysis will be the main analysis for this research. The aerodynamics analysis may cover entire part of the cars including bodywork and wheels. This project may use CFD software for aerodynamics simulation and detailed analysis. The software used for CFD analysis is Fluent 6.2.
- Fabrication: Rapid Prototyping used for fabricate a model for wind tunnel testing.

- Wind Tunnel Testing: After fabrication has completed, wind tunnel analysis will proceed. Wind tunnel used for this study is UTeM's subsonic wind tunnel.

Element that may not be covered in this project are:

- Material analysis such as stress analysis shall not be covered.
- Surface finish may not be cover in this study because of expensive materials.
- Ecstatic element will not be included in this research.

1.5 Benefits of Study

The CFD and wind tunnel analysis may able to clarify and gives better understanding for the student about the importance of aerodynamic effect. It also gives the reader an idea to overcome the drag force and also low in negative lift force.

From this report, hopefully this project may give them (participating school) a guide line for design consideration and better analysis the main element in "F1 in School".

Figure 1.0: Race day of F1 in Schools

(Source: By Author)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, all terms in this study shall be defined and some explanations of the term may take place. This chapter may discuss about the "F1 in Schools", the definition of aerodynamic, the CFD usage and application, fabrication and wind tunnel test.

2.2 F1 in Schools

"F1 in Schools" was founded in 1999 by Andrew Denford. "F1 in Schools" first established only at United Kingdom during year 1999 until 2003. In 2004, the "F1 in Schools" was introduced to many countries across the globe and accepted widely. The "F1 in Schools" competition is about 3 years old in Malaysia. During the first year in 2006, Malaysian team managed to get the "Fastest Car" award and break the record which was 1.083 second [5].

"F1 in Schools" is a small car made from Balsa wood which is light weight wood [18]. The used of balsa wood is suitable for "F1 in School" because the density of the balsa wood is around 100 to 200 kg/m^3 or typically 140 kg/m^3 which is 1/3 less density of hard wood. The main driver of the "F1 in School" is compact compressed reclaimed CO_2 power plant. The six elements for "F1 in School" are; business plan for acquiring sponsors, designing using CAD, analysis using CFD, fabricating using CNC machine, wind tunnel testing, and race [5].

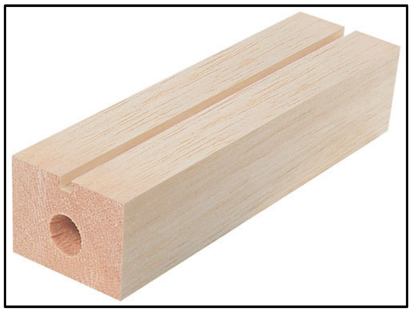

Figure 2.0: Blank balsa wood
(Source: Rules and Regulation 2008 Season, [10])

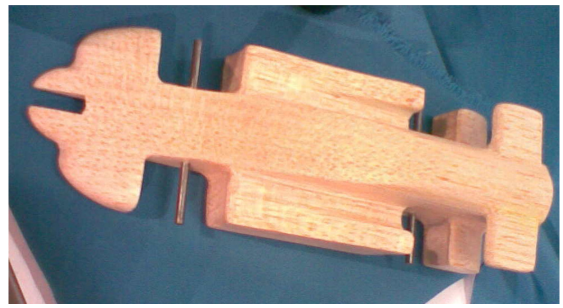

Figure 2.1: Balsa wood after machined
(Source: By Author)

Competitors came from all over the world has to compete in national stage before selected to represent for their country. All of them using same rule and regulations and the criteria for marking such as specifications, design portfolio, team design for F1 cars, used of CAD and ICT, and quality of manufacturing [5].

The interesting is, the main factor which can make the car be a fastest car is the aerodynamic of the car. The car which can cut the air smoothly through the straight line about 20 meters (m) can become the fastest car. In the "F1 in School" track record hold by Team Fuga from Northern Ireland in 2007 at Melbourne Australia venue. The time recorded is 1.020 second (s) [5]. The velocity of the car is 19.608 m/s which equal to 70.589 km/h.

Basically, the car was placed onto the track and a string will be attached to the screw pin underneath the car for guidance. The acceleration builds up from the force generated from CO_2 cartridge until the pressure depleted. The cars keep on cruising until it reached the halting cushion. Each car may give different timing because the drag produced by each car may different. The possible element that