UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPROVEMENT AERODYNAMIC DESIGN FOR C-SEGMENT CAR

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Industri automotif sekarang bersaing dalam mereka bentuk kenderaan bukan hanya dari segi menarik perhatian pelanggan tetapi juga mempunyai prestasi aerodinamik. Kelebihan utama aerodinamik adalah mengurangkan penggunaan bahan bakar atau tenaga enjin. Matlamat projek ini adalah untuk mencapai nilai pekali seret aliran angin (Cd) yang rendah daripada nilai reka bentuk yang sebenar melalui kaedah kejuruteraan songsang keatas kereta model Proton Inspira dalam nisbah 1:32. Kaedah kejuruteraan songsang dijalankan ke atas projek ini dimulai dengan proses pengimbasan 3D dengan menggunakan REXCAN C2 Plus sehinggalah menjadi model lukisan CAD. Reka bentuk kereta yang sebenar akan direka bentuk semula untuk mencapai nilai pekali seret (Cd) yang rendah. Nilai pekali seret (Cd) diperoleh melalui simulasi Pengiraan Dinamik Bendalir (CFD). Data terendah nilai pekali seret (Cd) daripada sampel reka bentuk akan dibandingkan berdasarkan ciri-ciri informasi yang dikeluarkan oleh CFD. Nilai pekali seret (Cd) dapat dikurangkan daripada 0.35 ke 0.33 selepas proses mereka bentuk semula pada bahagian but kereta. Nilai pekali seret (Cd) berubah apabila daya seret dikurangkan berdasarkan permukaan CAD kereta mestilah mempunyai ciri-ciri kelancaran untuk aliran angin.

ABSTRACT

Current automotive industry challenging to create design not only attracted to consumers but having performance in aerodynamic. Major benefit of aerodynamic to reduce fuel consumption. The purpose of this project used to achieve low drag coefficient (Cd) than actual design by reverse engineering method of C-segment of Proton Inspira car model 1:32 ratios. This project performed reverse engineering method, start with 3D scanning process by using REXCAN C2 Plus to the drawing model CAD. The actual design redesigned to reach low drag coefficient (Cd). The drag coefficient (Cd) of this project get from running the Computational Fluid Dynamics (CFD) simulation. Besides, the lowest drag coefficient reached performed SLS 3D Printing in car model size. The actual design as a reference of the design sample to reduce drag coefficient (Cd). The lowest drag coefficient data of design sample compared according to feature result of the CFD output. The drag coefficient of actual design reduced from 0.35 to 0.33 after the redesign process performed at trunk of the car. The drag coefficient changed after reducing drag forces based on the CAD surface of the car must smooth to the wind flow effortlessly.

DEDICATION

To my beloved parents, I cannot forget support that you give to me since child until becomes an adult. In that period time, I learned many things from your guidance. Also, non-stop gives inspiration, loving and prayers for my success and my happiness. Besides, not forget to individuals help me, such as my friends and respected lecturer especially to my supervisor. All kindness will always remember by me.

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Besides that, I would like to acknowledge and give a special thanks to my friends for giving support whenever I need help. Lastly, I would like to thank all my lecturer that have great level of patient in facing my bad attitude and taught me throughout my study at Universiti Teknikal Malaysia Melaka (UTeM).

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURES

Cd	Drag coefficient
CFD	Computational Fluid Dynamics
SLS	Selective Laser Sintering
m3	Millimetre cube
GSD	Generative Shape Design
Cx	Coefficient
3D	3 Dimension

CHAPTER 1

INTRODUCTION

1.0 Background

In this chapter will introduce the project by improvement, optimization and designing of the aerodynamic for C-segment type car. Idea develops in this chapter including introduction, problem statement, objective and scope of the project.

1.1 Introduction of the Project

Aerodynamic is the path of objects travels through the air. All objects in motion are influenced by aerodynamic. Since the air exists surround, even the car is affected by aerodynamic. Force of drag and lift are related to aerodynamic, solid bodies are passing over and around by air causing. Not only on vehicles, engineers also apply the aerodynamic principle includes on bridges, buildings and even on a soccer ball for sports entertainment.

The primary purpose of this project is based on automotive aerodynamic. The aerodynamic at first of history only apply on a racing car or aeronautic industries. The powerful of the car became faster that depends on the engine, but the wind affected on the automotive design is the factor prevents the engine achieve their actual speed. Aerodynamic is realized by an automotive engineer.

Early design applies on automotive created according aeronautical practice, design adapted from marine architecture based in Figure 1-1 (Hucho 1993).

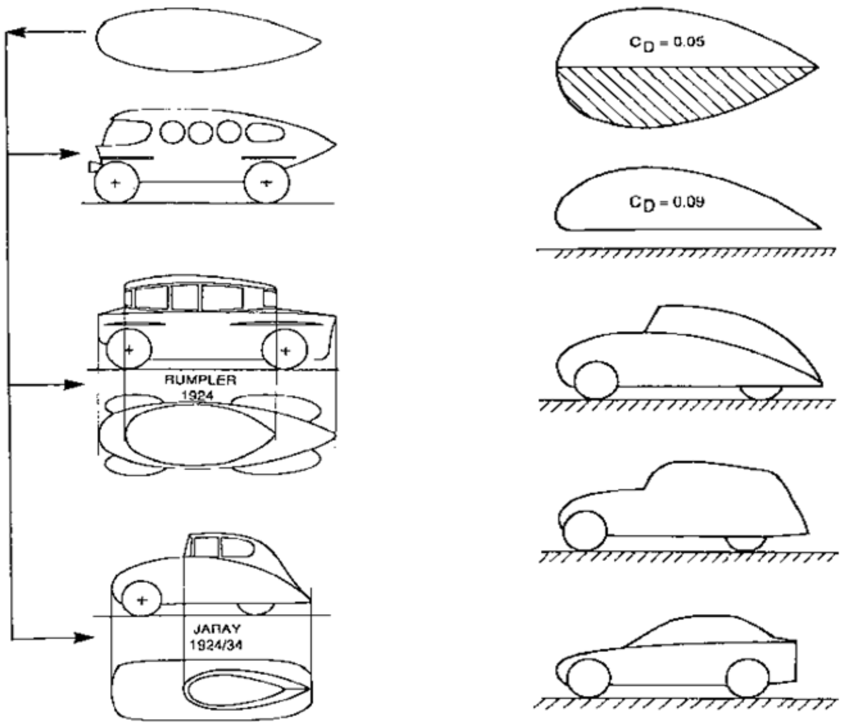

Figure 1-1: (Left) the design adapted by maritime and aeronautical practice and (Right) the revolution of automotive streamline shape.

This project performed reverse engineering on a car model. The car model picked by C-segment type of Proton Inspira in 1:32 scale ratios. The result of this project getting from Computational Fluid Dynamics (CFD) analysis. Autodesk Flow Design apply to get reading record of drag coefficient (Cd) and pressure data. The actual design will be under improvement after analysis performed. The redesign process creates used surface area in high affected pressure.

The suitable design surface studied to make more advance for aerodynamic. Drag coefficient get from air streamline cannot flow well outside of the car depending by the shape of vehicle (Eckert et al. 2014). Lastly, the result of the new design and actual used to compare lower drag coefficient (Cd) and the contribution for high pressure on the design surface.

1.2 Problem Statement

Currently, the automotive industries compete to make an innovation primarily on technologies according to compatibility to this era. This innovation to make improvement from many aspects such as fuel consumption, safe to the environment and safety control system. Nowadays, it becomes a trend in automotive industries to making improvement on weight reduction of the car and reduces fuel consumption either one electric car.

Based on the findings on the Motoring Research website, this website declares that 2013 Mercedes-Benz CLA and 2017 BMW 5 Series with the lower drag coefficients it is 0.22Cd (Redfern 2018). Both of this model do not belong to C-segment car, it was higher than C-segment type. Thus, it clearly shows a C-segment car type suitable to innovate for improving the aerodynamic surface design.

Primarily, the problem statement will be focused on the redesign aerodynamics surface for the C-segment car base. Second, area on car surface have mostly used contribute drag force. Then, the speed of the car will increase at the same time to reduce drag coefficient (Cd).

1.3 Objective

The objective of this project follows: -

a) To improve design of C-segment type through the reverse engineering methods of 1:32 scale ratios car model.

b) To analyze C-segment car type achieve minimum drag coefficient (Cd).

c) To fabricate the low drag coefficient car model Proton Inspira of C-segment type by using Farcoon SS402P Selective Laser Sintering (SLS) 3D printer machine.

1.4 Scope

The scope of this project follows: -

- Reverse engineering performs by using REXCAN CS2 Plus for 3D scanning process to get 3D point cloud data.
- Improvement of C-segment car (Proton Inspira) design at the trunk lid surface by using CATIA V5 to reach low drag coefficient than actual design getting by reverse engineering.
- Running Computational Fluid Dynamics (CFD) simulation on 3D CAD Part of C-segment car (Proto Inspira) using Autodesk Flow Design Software.
- Fabricate car model have low drag coefficient using Selective Laser Sintering (SLS) 3D printing machine.

CHAPTER 2

LITERATURE REVIEW

2.0 Background

In this chapter, all information about improving the aerodynamic design on C-segment car type are getting on relevant previous journal or research will be explained based on flow cart in Figure 2-1. This chapter to collect source will be recycled and to make innovation for a project.

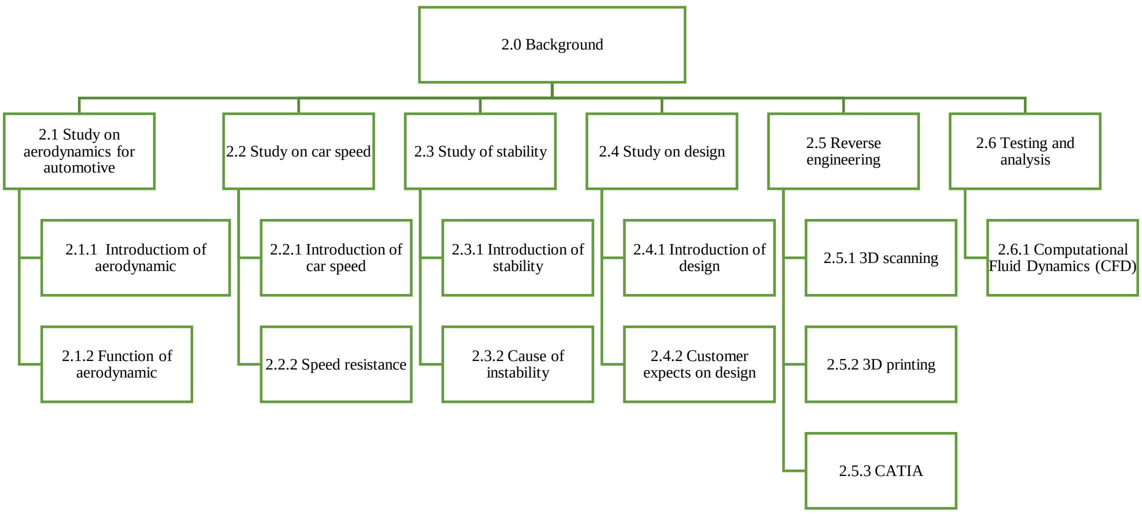

Figure 2-1: Flow chart of Literature Review

2.1 Study on Aerodynamic for Automotive

2.1.1 Introduction

The relative motion between the vehicle surfaces and the surrounding air produce by a result of the aerodynamic drag acting on a vehicle. Air aside pushes by the front vehicle is resulting for pressure increase. Pressure drop caused by air molecules cannot flow smoothly together at the rear side. The form drags get from the addition of these pressure differences. Longitudinal axis because of both wind and approaching traffic are not equaling with airflow around a stirring vehicle. The combination of the driving speed and the speed of the wind to get a relative flow speed (Juhala 2014).

Aerodynamic drag equivalent stands for a split among shaped upper surfaces and the remaining less visual components of a type of passenger car including; wheel arches, wheels, underbody and cooling airflow. The rear of the car body occurs the major drag component at the upper of the surface will surpass half the drag of the shaped surfaces, controls skin friction, protuberances such as mirrors and the front end drag (Howell 2013).

Vehicle shapes are acting to minimize the resistance of air flow and optimize aerodynamic lift with apply aerodynamic emphasized on vehicle geometry to perform dynamic road-behaviour requirement (Juhala 2014).

2.1.2 Function of Aerodynamics

Aerodynamic drag is the element used on relative velocity by force acting on a direction. The highlight for the coefficient, Cx is the sum of friction drag and form drag based on following in Equation 2-1 (Juhala 2014):

$$Fa = {}^{1}/_{2}\,\rho C_x A v_\tau^2$$

Where $v_\tau = relative\ air\ speed, A = frontal\ area, C_x = air\ resistance\ factor\ and\ \rho = air\ density.$

Equation 2-1: Formula of friction drag.

On higher speed and while driving on hilly roads it influences of mass increases. At high speed the aerodynamic role important on design (Juhala 2014).

The car can reach higher top speed and fast on straight road over air by dropping the drag. Design shape can produce downward pressure or downforce thru tires, it makes even in cornering car can maintain at high speed. The concept used for plane same as apply on automotive aerodynamic, but it applies in reverse from lift force to down downforce (Oxyzoglou et al. 2017).

2.2 Study on Car Speed

2.2.1 Introduction

Acceleration and high-speed turning rate will be improving by increasing normal downforce or aerodynamic on a vehicle. With essential to reduce the weight of the vehicle. Produce vehicle's body design can generate the aerodynamic force on the surface (Katz 2009).

Speed plays a role to bring substantial impact, 10 percent of the effects on performance consist of rolling resistance, weight and aerodynamics. Obviously, speed is a reason disturbing on aerodynamic performance (Juhala 2014).

At nearly speed of 50 km/h with increase in aerodynamic drag speed, the cause of drag on moving is proportional to the square of velocity, it major factors causing to the total drag experienced by the vehicle (Ansari 2017).

2.2.2 Speed Resistance

The technique used is concurrent engineering (CE). Almost worldwide automotive industries apply concurrent engineering to have benefit in terms of shortening time, higher quality product (CTQ) and cost reduction (Sapuan 2006).

Aerodynamic force used to prevent resistance forward motion of the vehicle. This making vehicle body move smoothly through surrounding air with lowest air resistance. It creates more stability with negative lift coefficient and low tire slip (Ansari 2017).

Vehicle body breaking air out of the way effect called frontal pressure. The effect of rear vacuum gets from air feature not able to fill hole left of vehicle frame. And