UNIVERSITI TEKNIKAL MALAYSIA MELAKA

NUMERICAL STUDY OF AERODYNAMIC PERFORMANCE OF DIMPLE ON COMMERCIAL BUS (PIONEER COACH BUILDER)

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

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Supervisor : Mohd Suffian Bin Abd Razak

ABSTRAK

Di zaman kini, peningkatan bahan bakar menjadikan pengangkutan jalan yang tidak ekonomi (Muthuvel et al., 2013). Projek ini membincangkan kesan kajian pengoptimuman bentuk lengkungan di atas permukaan bas dari syarikat Pioneer Coach Builder (PCB) sebagai alat pengurangan aerodinamik. Objektif projek ini adalah untuk membina data 3D reka bentuk bas dari Syarikat PCB. Untuk mencapai keperluan projek ini, data CAD dihasilkan daripada lukisan 2D bas PCB. Kemudian data reka bentuk 3D bas dapat dibina dengan mengubah suai pada permukaan bas PCB. Berdasarkan parameter yang diperoleh, model 3D bas PCB dengan pengubahsuaian optimum dengan lengkungan dibuat dan akan dianalisis. Seterusnya, matlamat kedua dan ketiga adalah untuk mengaplikasikan bentuk lengkungan yang mengoptimumkan di permukaan bas sebagai peranti pengurangan dan untuk mengesahkan prestasi bentuk lengkungan pada permukaan bas sebagai pengurangan aerodinamik ke arah penggunaan bahan api. Spalart-Allmaras akan digunakan untuk mendapatkan data. Dari hasil analisis ini, pengubah suaian ini dapat mengurangkan penggunaan bahan bakar. Peratusan bahan api yang digunakan untuk mengatasi pengurangan aerodinamik, G untuk model penanda aras dan optimum model adalah 0.3%. Oleh itu, objektif telah dicapai.

ABSTRACT

Nowadays, rising fuel make the road transport uneconomical (Muthuvel et al. 2013). This project deals with the study effect of Dimple Shape Optimization on the surface of the Pioneer Coach Builder (PCB) bus as a Drag Reduction Device. The objective of this project is to construct the 3D data of the bus design from Pioneer Coach Builder Company. In order to achieve this project requirement, the CAD data is generated which is from 2D drawing of PCB bus. Then the 3D data of the bus design can be construct with the optimize dimple on the surface of the PCB bus. Based on the parameter obtain, a 3D PCB bus model with optimize dimple was made and will be analysed. Next, the second and third objective is to apply the optimize dimple shape on the surface of the bus as reduction device and to validate the performance of dimple shape on the surface of the bus as drag reduction towards fuel consumption. Spalart-Allmaras will be used to obtain the data. From the analysing result, the drag coefficient will be calculated and reduced the fuel consumption. The percentage of fuel used to overcome aerodynamic drag, G for benchmark model and optimize model is 0.3 %. Thus, the objective had been achieved.

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LIST OF SYMBOLS

D, d	-	Diameter
F	-	Force
g	-	Gravity = 9.81 m/s
I	-	Moment of inertia
1	-	Length
m	-	Mass
N	-	Rotational velocity
P	-	Pressure
Q	-	Volumetric flow-rate
r	-	Radius
T	-	Torque
Re	-	Reynold number
V	-	Velocity
w	-	Angular velocity
x	-	Displacement
z	-	Height
q	-	Angle

LIST OF ABBREVIATIONS

PCA	Principal Component Analysis
CAD	Computer Added Design
PCB	Pioneer Coach Builder
BL	Boundary Layer
CFD	Computational Fluid Dynamic
CD	Drag Coefficient
CP	Pressure Coefficient
PD	Drag force
PR	Power Rolling Resistance
PT	Transmission Power Loses

CHAPTER 1

INTRODUCTION

1.1 Background study

The fuel consumption plays an important role in the development process of modern automotives. This is because fuel consumption is the main priority for the commercial vehicle such as buses, vans, lorries and trains when these vehicles started the journey. Fuel consumption of this vehicle not only affects the cost but also causes the greenhouse gas emission that pollute the environment. The exterior styling and aerodynamically efficient design for drag reduction which reflects in the reduction of fuel consumption are essential factor in commercial vehicle. Recently, there are many methods is used to reduce the fuel consumption such as adding wind deflector, spoiler and dimple. The main purpose in this project is to study the effect of dimple shape optimization on the surface of the Pioneer Coach Builder (PCB) bus. The method that will imply in this project is by making a dimple shape on the surface of PCB bus. Thus, it will affect the drag reduction and reducing boundary layer separation. The place that will be cover is on the surface of PCB bus. The optimization of dimple shape is drawn by using CATIA software. 2D drawing of the PCB body bus which is Dragoes-III is drawn by using AutoCAD software and then 3D model drawing is generated by using CATIA software. The dimple drawing combined and attached to the PCB bus drawing. Next, the drawings are being transferred to Hyperwork software which is AcuConsole to be mesh. After mesh generation, the drawing is simulate by using Computational Fluid Dynamics (CFD) to analyse the boundary separation and to get numerical data. Virtual Wind Tunnel is used to simulate and

analyse the PCB bus drawing model. The drag coefficient will be given from simulation of CFD and the data is used from Spalart-Allmaras in order to get the accurate position to be attached on the surface of PCB bus. Therefore, new drag coefficient will achieve and fuel consumption can be calculated.

1.2 Problem Statement

The extensive environmental debate of today forces vehicle manufactures to develop new concepts with lower fuel consumption and emission levels than ever before (Larsson & Martini, 2009). The major things that contribute more costing in transportation is fuel consumption. With the increasing automobiles industry, many vehicle manufactures especially bus company tend to reduce fuel consumption in order to improve aerodynamic performance and keep developing the fuel efficiency on ground vehicle (Y. Wang et al., 2014). Moreover due to increasing of oil price, high demands bring forward automobile design especially to aerodynamic characteristics of automobiles (Siva & Loganathan, 2016). The improvement of aerodynamics performance of bus can be achieved by reducing drag coefficient. The reduction of drag coefficient of bus depends predominantly on the shape which related with boundary layer separation. (Chow, 1998) stated that minimizing the pressure drag amounts can prevent or delaying boundary layer separation. One way of delaying separation is by forcing boundary layer to become turbulent. This is because when lowering the drag pressure will reduce the thickness of boundary layer.

Recently, there are many ways to reduce the drag reduction for fuel consumption such as redesign the shape or adding object in order to reduce the

thickness of boundary layer separation. Since the latter is usually dominant at high Reynolds numbers, various schemes have been invented for producing turbulent boundary layers (Bakker, 2006). In this study, addition of dimple on top of the bus will reduce drag coefficient (Abdul Latif, N M Zain, & Azhari, 2017).Thus, it will reduce the boundary layer separation on the bus (Chear & Dol, 2015). Boundary layer separation has significant effect on wake region as the drag coefficient is decreases (Gopal & Senthilkumar, 2013).

In this project, I study the effect of dimple shape optimization on the surface of the bus. The optimization on the design of the bus can be reduce the drag coefficient by 20 % (Devesh et al., 2017). The main purpose of this project is to reduce fuel consumption related to drag reduction and boundary layer separation. Hence, the improvement of the fuel efficiency can be achieved and have a high impact on the reduction of annual fuel consumption (Muthuvel et al., 2013). Regarding to industry collaboration with Pioneer Coach Builder bus company in this project, there will have high impact for them which is can reduce the fuel consumption cost and thus will help the company to gain more profit.

1.3 Objective

1. To construct the 3D data of the bus design from Pioneer Coach Builder company.
2. To apply the optimize dimple shape on the surface of the bus as reduction device.
3. To validate the performance of dimple shape on the surface of the bus as drag reduction towards fuel consumption.

1.4 Work scope

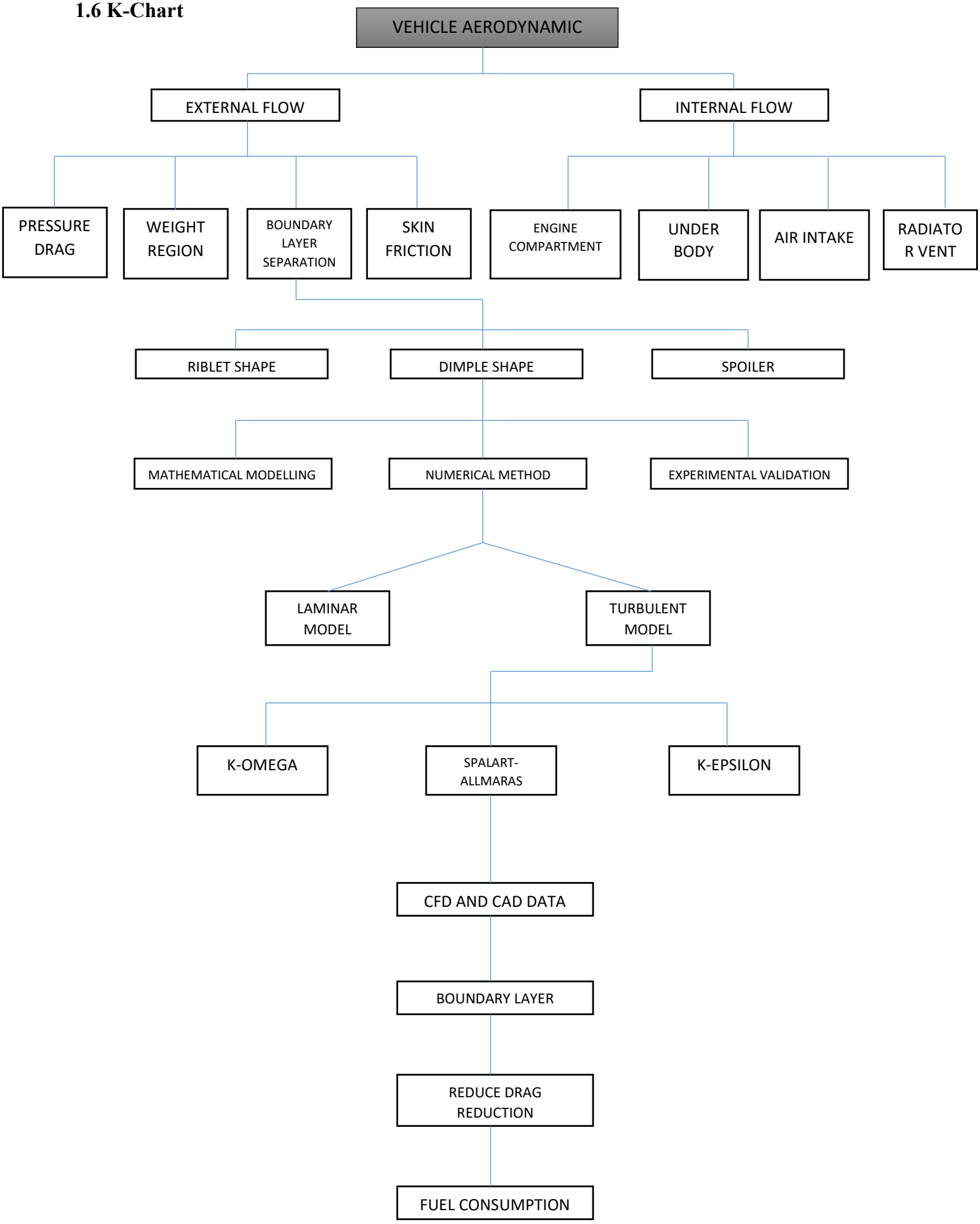
The main purpose of this project is to study the effect of dimple shape optimization on the surface of the bus. The top and side exterior of the bus will be covered in this project. The interior and engine modification will not be included in this project because only dimples will affect the boundary layer separation and will reduce the drag coefficient. The bus is targeted as main study in this project and CAD drawing of bus is needed. CAD generation of general bus are specific only at Pioneer Coach Builder company. Then, the application of dimple shape only apply on the surface of the Pioneer Coach Builder bus. The dimple design depends on the finding and only optimize dimple will be used. The 3D data of the bus with optimize dimple which is from CAD drawing is simulate using CFD to get drag coefficient result. The simulation use variation of speed in order to get different data. Based on the coefficient drag result, the fuel consumption of Pioneer Coach Builder bus can be calculated. In this project, the study of the effect of dimple shape on Pioneer Coach Builder bus is limited to numerical method.

1.5 Expected Result

From this project, we can see the difference between the optimization of dimple shape and benchmark result. The optimizations of dimples shape have less drag coefficient than benchmark result. Thus fuel consumption will reduce using the optimization of dimple shape. The different parameter of dimple shape will contribute to change to of drag coefficient on 3D model of Pioneer Coach Builder bus and fuel

consumption. Result expectation on this project is to reduce fuel consumption 5% to 10%.

1.6 K-Chart



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A large and growing body of literature has investigated and studied earlier on dimple shape optimization using DOE of Ahmed body on the surface as a drag reduction device. However, the continuity of the study on this literature review followed by the dimple optimization on the surface of actual bus (Pioneer Coach Builder bus) as a reduction device will be further discussed. In 2016 (Stanly, S, Suneesh, & V, 2016) published a journal in which they described it has been experimentally proven that just as the dimple on a golf ball helps in reducing its drag, it helps to reduce the drag on a vehicle when it is imparted to it in the proper way. (Libii & Wolf 2014) stated that the dimple is one of the method to reduce the drag force cause by air. Size, arrangement, depth and form of dimple are various can be implemented (Naruo & Mizota, 2014).Moreover, (Chear & Dol, 2015) stated that different parameters like dimples position, number of dimples, dimples orientation will be tested in order to fully understand the performance of the dimple application on vehicle aerodynamics. In this study, the dimple will be implemented on the top and side surface of actual bus.