UNIVERSITI TEKNIKAL MALAYSIA MELAKA

NUMERICAL STUDY OF ENGINE AIR INTAKE AIRFLOW PERFORMANCE 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) with Honours.

by

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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

Sejak kebelakangan ini, aerodinamik memainkan peranan penting dalam merekabentuk sesuatu kenderaan automotif. Industri automotif juga lebih tertumpu dalam rekabentuk aerodinamik pada kenderaan darat iaitu kereta, bas dan lori. Rekabentuk aerodinamik ini sebenarnya akan mempengaruhi aliran udara pada kenderaan. Gril merupakan komponen yang akan membenarkan aliran udara masuk kedalam bahagian komponen dalaman kenderaan dan juga bertindak sebagai sistem penyejukan. Biasanya gril untuk kenderaan akan dipasang pada hadapan, tetapi untuk bas ianya terletak di tepi dan di bahagian belakang bas kerana kedudukan enjinnya terletak di bahagian belakang yang berbeza untuk dibandingkan dengan kereta dan lori. Selain itu, gril juga bertindak sebagai sebagai pelapik yang melindungi sistem pengambilan udara dari apa-apa keadaan persekitaran seperti hujan dan melindunginya daripada batu dan bertindak sebagai penapis habuk. Dalam kajian ini, model bas Pioneer Coach Builder (PCB) akan digunakan dan ianya akan direkabentukkan menggunakan perisian CATIA V5. Perhatian hanya diberikan kepada rekabentuk luaran yang tertumpu pada gril pengambilan udara bas, manakala bahagian dalaman tidak akan diubah dan dimodelkan. Oleh yang demikian, matlamat kajian ini adalah untuk merekabentuk semula gril pengambilan udara menggunakan perisian CATIA V5 untuk menyiasat pengagihan prestasi aliran udara pada gril masukan dan mengesahkan keputusan simulasi dengan melakukan ujian fizikal menggunakan data “wind tunnel”. Selain itu, perisian Computational Fluid Dynamics (CFD) akan digunakan sebagai perisian simulasi dalam kajian ini sebagai penyelesaian paling berkesan untuk menganalisis aliran udara pada sistem pengambilan udara pada enjin.

ABSTRACT

Lately, aerodynamics plays an important role while designing any automotive vehicle. Automotive industry has more interest in the aerodynamic shaping on road vehicles which is including cars, bus and trucks. This aerodynamic shape actually will influenced the airflow on the vehicle. Grille is a component that will allow air flow inside the underbody component and also act as cooling system. Usually grille for vehicle will be mounted on the front end of automobile but for bus it is located side and the back of the bus due to the position of the engine compartment that is located at the back that is different from cars and truck. It also acts as a protecting guard from any surrounding condition such as rain and protect it from rock and act as filter from dust. In this study, a Pioneer Coach Builder (PCB) bus model is considered and it is modelled using CATIA V5 software. Attention is only given to the external design that focus on intake grille shape of the bus, while the interior is not modelled. Therefore, this aim of this study is to redesign the intake grille shape using CATIA V5 software to investigate the airflow performance distribution on the intake grille and verifying the simulation result with the physical testing using wind tunnel data. Furthermore, Computational Fluid Dynamics (CFD) software is used as a simulation software in this study as the most cost effective solution for intake airflow analysis on the engine intake system.

DEDICATION

I dedicate this report to my beloved guardians Mr. Abdul Murad bin Abd Hamid and Mdm Nor Azleen binti Saiman. Not forgot to my supervisor Mr. Mohd Suffian bin Ab Razak and my automotive studio analysis laboratory technician, Mr. Azrul that gives me a chance to use the laboratory under his supervision. I also want to dedicate this dissertation to my lecturer Mr. Mohd Faruq Bin Abdul Latif who will to teach me and assist me to complete this research. I also would like to dedicate to all my friends for giving the assistant, support and underpins in completing this study.

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First of all, I would like to thanks and appreciation my supervisor Mr. Mohd Suffian bin Ab Razak for his guidance to finish this final year project. Special thanks also dedicated to Mr. Mohd Faruq bin Abdul Latif to helping me during the progression of this study and encouragement towards the completion of this study.

From the bottom of my heart, my deepest gratitude is expressed to my beloved father Mr. Abdul Murad Bin Abd Hamid and my beloved mother Mdm Nor Azleen Binti Saiman and all my friends

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LIST OF SYMBOLS

D, d	-	Diameter
m	-	Mass
N	-	Rotational velocity
P	-	Pressure
Re	-	Reynold number
V	-	Velocity
w	-	Angular velocity
x	-	Displacement
q	-	Angle
H	-	Height
L	-	Length
W	-	Width
E	-	Length Of Back Slant
R, r	-	Radius Of The Roundness

LIST OF ABBREVIATIONS

PCB	Pioneer Coach Builder
CFD	Computational Fluid Dynamics
CAD	Computer-Aided Design
CD	Drag Coefficient
CL	Coefficient of Lift
CO2	Carbon dioxide
AIS	Air Intake System
FD	Finite Differences
FV	Finite Volume
FE	Finite Element
DNS	Direct Solution Of The Navier–Stokes Equations
LES	Large-Eddy Simulation
PC	Personal Computer
Re	Reynolds Number
CAE	Computer-Aided Engineering

CHAPTER 1
INTRODUCTION

1.1 Background

The commercial bus usually has a small size of grille ventilation for intake compare to the truck and car. Poor of airflow for the engine intake can lead to reducing engine performance and lifetime of the engine. This is because airflow performance for engine air intake is important for every vehicle. The design of intake grille is the main contributor for a good airflow performance for engine intake system. The function of the grille is to allow and give as much of airflow to the engine intake system for combustion process hence the airflow has a direct impact on the power the engine can deliver. There are several types of grille design that vehicle manufacturer had been used in recent years such as the perforated grille, cross-hatching grille, vertical grille, horizontal grille, and honeycomb grille. This grille design not just influence the airflow, it also helps to filter and protect the intake system from getting any unwanted dust, water, and rock that will affect the performance if it is entering the engine intake system. Bus intake grille usually located at the back side along with the engine compartment. The advance in airflow is partly reflected in the increase in engine intake performance. The method that will apply in this project is by making a grille shape on the side of the Pioneer Coach Builder (PCB) bus. By using CATIA software, 3D model drawing is generated, and the model can be tested, grilled position and grille shape need to be redesign to improve and allow maximum airflow performance for the engine air intake. Computational Fluid Dynamics (CFD) is used to analyze the design effectively and get the numerical data to achieve

better airflow performance at the side of the bus. The virtual wind tunnel is used to simulate and analyze the altered grill shape design for the PCB bus drawing model.

1.2 Problem Statement

Aerodynamic styling and encapsulation have led to airflow reduction in front openings, due to this lesser quantity of air enter in the engine compartment like intake manifold (Kulkarni, Deshpande, Umesh, & Raval, 2012). The airflow through vehicle subsystems such as the grille, bumper, hood-latch baffles, the heat exchangers, the fan and shroud is called as front-end flow according (Baskar & Rajaraman, 2015). The front grille must guide the appropriate amount of airflow to the under bonnet compartments to the engine intake (Sareh Pooya, 2016). Then, the airflow efficiency of the intake system has a direct impact on the power of the engine can deliver. Next, Optimize intake system and filter duct area, understanding of flows and pressure drop through the system is essential. (Ramasamy, Zamri, Mahendran, & Vijayan, 2010). Reducing restriction is the simplest technique to enhance the air flow of air intake (Rosli, Syabil, Mohd, & Mamat, 2013). Pioneer Coach Builder intake grille located at the side back of the bus. Because of different chassis have a different location of intake, the grille shape, and grille location will be affecting the airflow performance for the intake system.

The intake airflow is normally controlled by a grille which is carefully designed to direct the air into the engine chamber (Hutacharern & Ridluan, 2017). The simulation has shown that vehicle speed has an insignificant effect on the amount of air intake, and the grille blade setting at 45-degree gives the highest flow velocity into the engine bay (Hutacharern & Ridluan, 2017). Overall airflow field existing within intake has been captured that indicates the modification in airflow field with cowl deflection angle. Overall intake performance has been obtained (Das & Prasad, 2009). Optimizing the

geometry of an intake system to reduce the pressure drop and enhance the filter utilization area by adding guide vane when the pressure drop decreases, more air supply which generates more power (Ramasamy et al., 2010). At the point when the air admission was guided utilizing guide vane swirl and tumble device in front of the intake port, sorted out turbulent air was produced and eventually produce better performance (Saad, Bari, & Hossain, 2013). Computational Fluid Dynamics can be consider to be the best cost-effective solution for flow analysis of intake system (Safwan & Ahmad, 2009).

In this project, the effect of grilled shape on the intake airflow performance at the side of the bus will be studied. The main purpose of this research study is to improve airflow performance at the engine air intake. Building an air duct that has more flow features that can guide the air. When the pressure drop decreases, airflow is being quite freely admitted to the engine intake, so that more air and fuel is being supplied to it, which generates more power (Ramasamy et al., 2010).

1.3 Objectives

1. To construct the outer surface 3D data of the bus design from Pioneer Coach Builder
2. To apply the optimize airflow performance at engine air intake for the intake system.
3. To prove the airflow performance effect of grilled shape on the engine intake vent at the side of the bus for a better airflow on the intake system

1.4 Project Scope

The main aim of this research is to study the airflow performance on the engine intake vent on the side of the actual bus. Engine modification and the interior of the bus will not be included in this project because only the grille shape of the bus will affect the airflow

performance for the intake system. The bus is the main target of this project and CAD drawing for the bus is needed. The CAD generation of the commercial bus is specific only at Pioneer Coach Builder Company. Moreover, the airflow performance only applies on the grilled vent at the side of the Pioneer Coach Builder bus. The grilled vent shape design depends on the finding and only the optimize design airflow will be used. The 3D data of the bus with optimizing the grilled shape for the best airflow performance which is from CAD drawing is simulate using CFD to get the airflow performance for intake system. The simulation uses a variation of speed to get a different set of data. The airflow performance result of Pioneer Coach Builder bus can be calculated. In this project, the study of the airflow performance at the engine intake vent on Pioneer Coach Builder bus is limited to the numerical method and there's no physical testing will be applied on this study.

1.5 Result Expectation

From this study, we can see the airflow difference in the optimize grille shape. Airflow changes in grille shape will indicate which one is the best designs for air intake on the engine. This airflow performance will help the engine to better airflow and achieve better performance. The different parameter of intake grille shape will contribute to the change of airflow performance on 3D model PCB bus. Result expectation in this study is to identify which grille design will get a better airflow performance for the bus.

CHAPTER 2

LITERATURE REVIEW

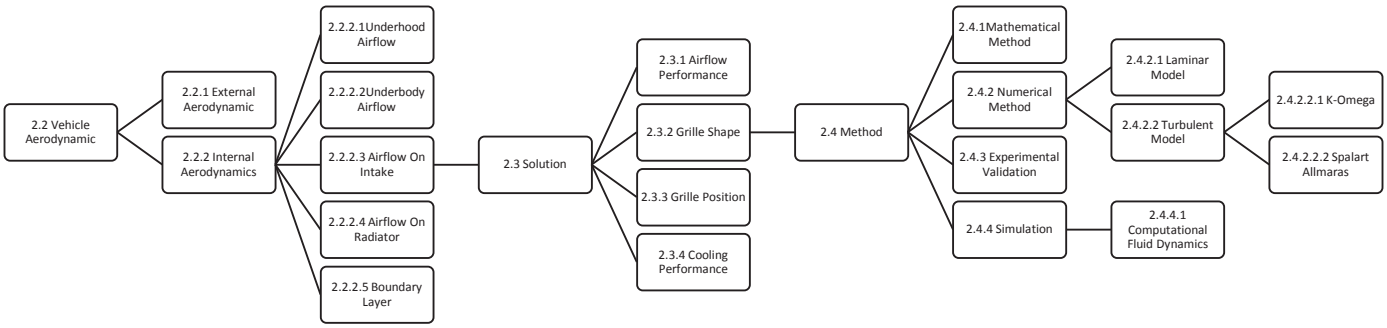
2.1 Introduction

Literature review purpose for this study is to review other research related to the study conducted to get the right idea and concept. The literature review also uses in this study to obtain a problem statement and suitable methodology.

The literature review flow of this study was illustrated in the K-Chart. It starts with an introduction which consist of a brief history of vehicle aerodynamic. Then it is followed by the overview of external aerodynamic and internal aerodynamic which consist of the brief of the engine compartment, outer body, airflow intake, airflow radiator, and boundary layer.

The study is then converging to vehicle airflow intake. The fundamental theory was studied thoroughly. The study airflow performance, grille shape, and grille position were reviewed to enhance the factual knowledge.

K Chart



2.2 Vehicle Aerodynamics

In this recent years, the increasing development in vehicle aerodynamics within car manufacturer has been improved. Aerodynamics is used in science at the end of the 19th and the beginning of the 20th century which occupies four chronologically indistinct phases of basics shapes, streamlined cars, and detail optimization. The main factor that is contribute to the development of aerodynamics were doing experimental work, theoretical development, and development by the Wright Brothers of air flight and others. The main developments with vehicle aerodynamics occurred, and the use of low-drag vehicles has become common until now. In these past years, vehicle manufactures has designed the external shape of the vehicle for safety reasons, comfort improvement and also aesthetic consideration (Dumas, 2005). Main goals of aerodynamics are to reducing drag and wind noise, and aerodynamic instability at high speed of the vehicle. The ineffective aerodynamic shape will result in excessive drag which leads to increased fuel consumption rates.

The evolution of automobile design will continue to change from basic shape change to detail optimization over time and years. There are advantages of having good aerodynamics in a vehicle that is, vehicle has more fuel efficiency, the vehicle can achieve higher speeds, and the vehicle can have more stability when reaching higher speed and it also has a stylish appearance of the vehicle.

Figure 2.1 :La Jamais Contente (Dimitriadis, n.d.)

Vehicle aerodynamic is all started in Schaerbeek when Camille Jenatzy a Belgian who was a race car driver that first to design a car using aerodynamic principles. He invented La Jamais Contente that was the first road vehicle that broke the 100kph barrier in 1899 as shown in ***Figure 2.1***. This vehicle is electrically powered. About their geometry, road vehicles comprise a large variety of configurations. Passenger cars, vans, and buses are single bodies. Trucks and race cars are more than one body, motorcycles and some race cars have open driver compartments. With the race car being the only exception, the shape of a road vehicle is not primarily according to (Ts & Sovran, 1993)

To have more slippery streamlined designed shaped car the aerodynamics of a car can also be refined so there will be a point where a car's design with a high downforce set up, will be good in the corners but will have compromised top speed. This is not a desired aerodynamic design for production cars, as it will lead to higher fuel and tire/ tire consumption. (Ali, Khan, Mohan, & Mandape, 2014)

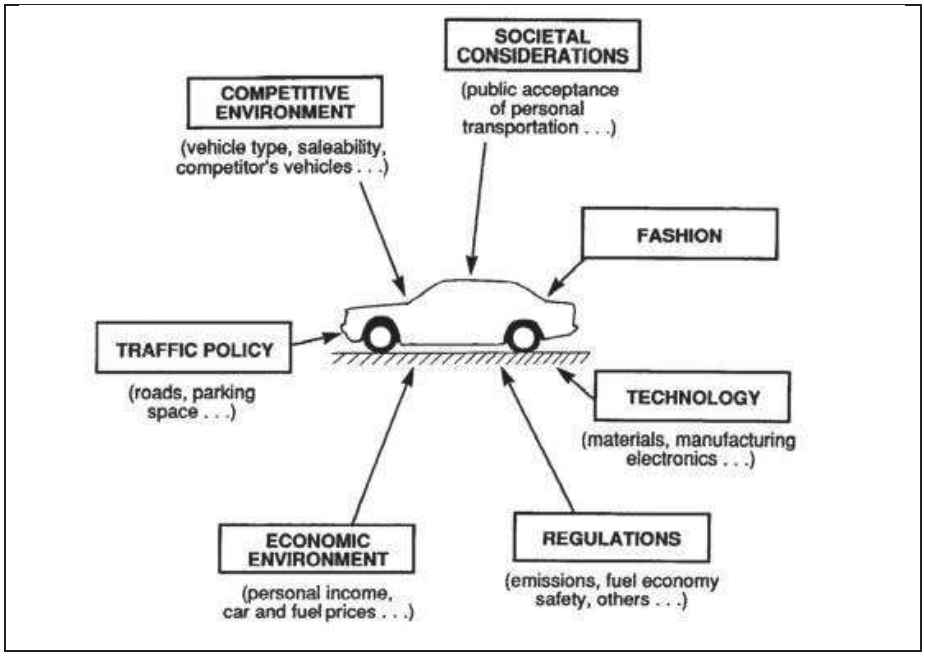


Figure 2.2: The concept of a car is influenced by many requirements of very different nature. (Ts & Sovran, 1993)

2.2.1 External Aerodynamics Airflow

External Aerodynamics is whre the simulation of fluid flow is taken at the external surfaces of an object such as a vehicle body to calculate the amount of drag and lift generated. External aerodynamics is the study of air flow at outer surface of solid objects in various shapes. Some examples of external aerodynamics test is when evaluating the lift and drag on an airplane or the shock waves that form in front of the nose of a rocket (Ali et al., 2014).

In automotive industry, the aerodynamic forces that are lift and drag force, play a huge part in affecting the vehicle's fuel efficiency and also improving handling capability. As we know, in motorsports worlds like drifting, drag and touring races, rear spoiler or wings and other aerodynamic devices is used. This improvement will be tuned to give a perfect balance between drag and downforce to improve the top speed, cornering and also braking grip while the vehicle being used on the track.