



## **UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

### **DESIGN AND EVALUATION OF BUS AIRCOND DUCTING SYSTEM FOR BETTERMENT USING NUMERICAL ANALYSIS**

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

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## ABSTRACT

Bus is a public transport that being used by local people to travel whether for short-distance or long-distance in almost every country. It is a convenient transport to travel around as the fee is cheaper than train and airplane besides having a comfortable seat to sit. There are complaints about the air conditioning system inside the bus as the system is too cold and the flow of air is strong. However, for mini buses, complaints have surface; stating that the front part is not cold and not getting the right comfort temperature. A research for mini bus relating to this matter is done in order to survey the comfort level of passengers in bus. By analyzing the comfort level, the current ducting system of a mini decker bus is evaluated. A new ducting system is designed for the bus to obtain a better airflow by using numerical analysis. Numerical analysis is consisted of following parameter; air flow rate and temperature. Those parameters are measured using anemometer and airflow meter. The data is analyzed using Solidwork and Hyperwork simulation. A new ducting system is created using the same software to get a better airflow in the bus.

## ABSTRAK

Bas adalah satu pengangkutan awam yang digunakan oleh orang awam untuk berjalan sama ada untuk jarak dekat mahupun jarak jauh di hampir setiap negara. Bas adalah pengangkutan yang mudah untuk dinaiki kerana bayarannya lebih murah berbanding keretapi dan kapal terbang di samping mempunyai tempat duduk yang selesa. Terdapat rungutan tentang sistem penyaman udara di dalam bas kerana sistem itu terlalu sejuk dan aliran udara yang deras. Bagaimanapun, untuk bas mini, rungutan telah diudarkan mengatakan bahawa bahagian depan dek tidak sejuk dan tidak mendapat suhu yang selesa. Satu ujikaji untuk bas mini mengenai perkara ini dilakukan untuk mengaji selidik taraf keselesaan penumpang di dalam bas. Dengan menganalisa taraf keselesaan, sistem salur udara yang sedia ada dinilai. Satu sistem salur udara baharu telah direka untuk bas bagi mencapai sistem salur udara yang lebih baik dengan menggunakan analisis berangka. Analisis berangka terdiri daripada parameter tersebut; kadar aliran udara dan suhu. Parameter tersebut diukur menggunakan *anemometer* dan meter aliran udara. Data tersebut dianalisis menggunakan simulasi Solidwork dan Hyperwork. Satu sistem salur udara dicipta dengan melibatkan perisian yang sama untuk mencapai satu sistem salur udara yang lebih baik.

## **DEDICATION**

I would like to express a special thanks to my mother, sisters and father for your unconditional love and support in everything. Thank you for giving me chances to improve myself through all my entire life and keep believing in me.



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# CHAPTER 1

## INTRODUCTION

### 1.0 Introduction

Bus, also known as coach, omnibus, multibus, motorbus and autobus is a land vehicle designed to carry many people. It has a capacity up to 300 people per bus. Several type of buses that passengers are used with are single-decker bus, double-decker bus, articulated bus and also minibus. Usually, people prefer bus over other public transport to travel a long distance as the bus is more spacious and more comfortable. As for minibus, the width is less than travel bus so there is difference in space. To drive a bus, ones have to obtain a special license because it is beyond a regular driver's license in which the bus needs skill to balance it. Buses can be utilized for scheduled bus ride, scheduled coach ride, school ride, private hire or maybe tourism. There is several type of buses available in Malaysia such as single-decker bus, double-decker bus, minibus or custom-bus. There is also open-roof bus type that give the opportunity for passengers to have a better view of surrounding's scenery. In south and west countries, triple-decker bus is available but rarely seen because that type of bus is not as much unit as single-decker and double-decker bus.



## 1.1 History of Bus

The first ever bus that made it on the road is a large, steam-driven bus in England. Earlier, bus is known as omnibus; a Latin word means “for all”. The earlier bus used to carry two to six person per bus but later was developed in order to carry more person in a single bus. (Chisholm, Hugh, 1911)

### 1.1.1 Steam Bus

The first bus service was started by steam-powered buses that were first discovered in England in the 1830s by Walter Hancock and by associates of Sir Goldsworthy Gurney. This type of bus is a mechanical bus which is mechanically propelled started its operation on road of London on 22nd April 1833. Steam carriages were much fewer prone to overturn as they travelled much faster than horse-drawn carriages and were likely more cost-effective and led to minor damage to the road surface attributable to their wide tires. (Eckermann and Erik, 2001)



*Figure 1.0 The first build of bus (Amédée Bollée, 1825)*

### 1.1.2 Trolley Bus

Trolley bus is a bus that uses two medium-sized tires at the front and two large tires at the back. It was invented parallel to the typical bus; trolley bus use electric to move which fed through trolley poles by overhead wires. This bus's idea was first popped from Sir William in an editorial back in 1881 and the belief was expanded and advanced by the Siemen brothers; William in England and Ernst Werner in Germany. (Charles S. Dunbar, 1967)



*Figure 1.1 Early trolley bus (Peter Dew, 2014)*

### 1.1.3 Motor Bus

A six-passenger motor carriage is invented by Benz Viktoria in 1893 and is utilized in 1895. The bus is generated with the internal kindling by a motor as a way to make it move. The idea of motor bus was then expanded by Daimler; among the folks that came out with earliest motor bus model. Daimler decided to design a double-decker bus using the same concept as motor bus model. His

double-decker bus was sold to Motor Traction Company and it was first landed on the road on 23rd April 1898 in London. (Benson, Bruce L, n.d)



*Figure 1.2 The design of early motorbus in 1900s (Charles E Lee, 2013)*

## **1.2 Background of Study**

Air conditioning system has becoming a need for people in order to feel comfort especially in a hot and humid country such in Malaysia. For bus, the first ever air conditioning system is designed for Volvo bus. The system consists of components compressor, condenser, evaporator, accumulator and orifice tube (Imam, 2013). As for delivering the cooled air, ducts are used. Thus, ducts system plays an important role for this part.

Ducting system is a system where there is several ducts that linked from A/C system to diffuser installed in a house, building and vehicles. Their main roles are to supply conditioned air to a room, cabin or to a building and to carry heat from the room to be

returned (return duct) to air handling unit (AHU) or to be thrown. Some buildings do not install return ducts to save the cost. In contrary, the building that not install return ducts practices natural return – grille is installed in the room but does not has the return duct because the heat will naturally go up to ceiling and flows back to AHU. Ducting system can be either installed at the ceiling or inside the wall depending on consumers' requirements.

Ductworks installed in buses is said to not have proper dimension and location of installation because different type of bus requires different layout of ducting system to fit the space provided. This action has resulting in uneven distribution of air inside the bus because of misplaced supply ducts. The study's main intention is to propose a proper design of ducting for a bus.

### **1.3 Problem Statement**

There are several complains from the bus passengers stating that the air conditioning inside the bus is too cold and the flow of air is too strong. However, there are some of the passengers feel hot because of uneven temperature distribution.

### **1.4 Objectives of Research**

The objectives of this research are:

- i. To evaluate the current ducting system of a mini bus

- ii. To design a new bus air conditioning's ducting system for betterment with selected parameter (temperature and airflow)
- iii. To simulate the new bus's ducting system for better air flow using numerical analysis

## 1.5 Scope of Research

Corresponding with the objectives above, this research's work scopes are:

- i. Type of researched bus is a mini bus (27 seaters minibus)
- ii. Air flow rate and temperature will be measured using anemometer and airflow meter
- iii. The data will be analyzed followed by running a simulation using Solidwork and Hyperwork
- iv. From the simulation, a new ducting system or renovated ducting system will be created using the same software for better air flow

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 Introduction**

A bus air conditioning system is made up from several components which are compressor, receiver dryer, thermal expansion valve, condenser and evaporator. Each component is made has its own function and ability.

Duct system or ductwork is installed to complement the air conditioning system for the bus as the duct system's function is to deliver and return the air from a space. The ducting parameters to be considered air flow velocity and temperature. Both parameters affected passengers in term of thermal comfort.

## **2.1 Compressor**

Compressor is like the “heart” of A/C system that works like a pump to pump refrigerant and pressurize it and then letting it strike to the evaporator.

According to K.Kolmetz, among the earliest recorded uses of compressed gas (air) dates back to 3rd century B.C. The early uses of compressed air was known as water organ. The water organ consisted of a water pump, a chamber partly packed with air and water, a row of pipes on top (organ pipes) of various diameters and lengths plus connecting tubing and valves. By pumping water toward the water/air chamber the air becomes compressed. This approach was further improved by Hero of Alexandria (also noted for describing the rules of expanding steam to turn steam power to shaft power). (Kolmetz, 2011)

### **2.1.1 Type of Compressor**

Compressors are classified into two categories that are positive displacement and dynamic. Compressor is usually located at the back part of a bus along with engine system.

From American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Guideline 23P, compressor should be selected such that it operates within speed (if variable), suction and discharge pressure parameters recommended by the compressor manufacturer for optimum operating efficiency and life. When available, it is recommended to use a system simulation program to verify that all compressor and system operating parameters remain in a safe