This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours

by

SYAZWAN BIN SUKRI
B071410098
920618-03-5945

FACULTY OF ENGINEERING TECHNOLOGY
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DECLARATION

I hereby, declared this report entitled “Development of Volatile Organic Compound (VOC) removal filter (prototype) for transport air conditioner” is the results of my own research except as cited in references.

Signature : ……………………………………………………
Author's name : SYAZWAN BIN SUKRI
Date : ……………………………………………………
This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Refrigeration and air conditioning system) with Honours. The member of the supervisory is as follow

……………………

(NORAIN BINTI IDRIS)
**ABSTRAK**

ABSTRACT

Vehicles are an important transport system and have been increase about twenty nine percent in Malaysia. But there has a problem about Volatile Organic Compounds (VOC) inside the vehicles that caused by passengers and driver itself. There already have air filter inside car air conditioner that to remove the harmful particles and contaminants from the air but not filter out the Volatile Organic Compounds (VOC) from air inside the cabin car. Therefore, VOC removal filter has been construct to solve the problem. Charcoal has been use for develop this filter to remove VOC contains inside air. The size of design is 16 cm (W) x 16 cm (L) and the thickness is 3 mm, according to actual size of air filter for Myvi car air conditioner. After the completion of design process, the next process is to make a fabrication of the prototype based on the design and drawings that has been made. For the material has been used for VOC removal filter is 200 gram of charcoal, polypropylene fabric and trilling netting small. When fabrication complete, the process will continue with the testing process where it will test the percentage of VOC will be remove by VOC removal filter at the car air conditioner without removing the actual filter. VOC removal filter prototype will be test using three odor sources is cigarette smoke, oil paint and petrol. The data will be taken for every sixty minutes with the time intervals of ten minutes. The data are used calculate the average value of the VOC level and its percentage differences for cigarette smoke, oil paint and petrol is 15.27%, 4.34% and 3.69%. From data percentage of Volatile Organic Compounds reduction, it is proven that the new VOC filter prototype is capable in reducing the Volatile Organic Compounds in the air that cannot be done by conventional filters.
ACKNOWLEDGEMENT

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**LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE**

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<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AHU</td>
<td>Air Handling Unit</td>
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<tr>
<td>MERV</td>
<td>Minimum efficiency reporting value</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigerating and Air-Conditioning Engineers</td>
</tr>
<tr>
<td>EN</td>
<td>European standard</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>TXV</td>
<td>Thermostatic Expansion valve</td>
</tr>
<tr>
<td>IAQ</td>
<td>Indoor air quality</td>
</tr>
<tr>
<td>HEPA</td>
<td>High efficiency particulate air</td>
</tr>
<tr>
<td>UV</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>DOC</td>
<td>dissolved organic carbon</td>
</tr>
<tr>
<td>RO</td>
<td>reverse osmosis</td>
</tr>
<tr>
<td>FFT</td>
<td>fast Fourier transform</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, ventilation and air conditioning</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society of Testing and Materials</td>
</tr>
<tr>
<td>NO2</td>
<td>nitrogen dioxide</td>
</tr>
<tr>
<td>VOC</td>
<td>volatile organic compounds</td>
</tr>
<tr>
<td>TVOC</td>
<td>total volatile organic compounds</td>
</tr>
<tr>
<td>GAC</td>
<td>Granular activated carbon</td>
</tr>
<tr>
<td>mm</td>
<td>millimeter</td>
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<tr>
<td>ml</td>
<td>milliliter</td>
</tr>
<tr>
<td>µm</td>
<td>micrometer</td>
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<tr>
<td>ppm</td>
<td>parts per million</td>
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CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter explain briefly about the whole of the project Development of VOC Removal Filter Prototype for Transport Air Conditioner. This chapter consist of background of study, problem statement, objective and scope.

1.1 Background

Vehicles are an important transport system and have been increase about 29 percent in Malaysia (Mohd 2012). All vehicles in Malaysia use air conditioning system to ensure human comfort level is in standard range. Air conditioning system create a comfortable cool air for environment by controlling the temperature of the air, humidity and indoor air quality (Oh et al. 2014). There are four main components of vehicles air-conditioning systems which are compressor, condenser, evaporator, and throttling device. For cars air-conditioning system duct is used to distribute the cool air to the conditioned space. This is similar to building air-conditioning system which use air handling unit (AHU). To provide thermal comfort in required space in vehicles there have their main components such as cooling, heating apparatus, air filter and fan. Each component has their own function for the system. Air filter acts as barrier to avoid of harmful particles
and contaminants from the air to provide clean air to a conditioned space (Boni & Clark 2008).

Air filter is also important in car air-conditioning system where it can clean the indoor air quality (IAQ) in driver and passenger space. Besides that, air filter can avoid the driver and passengers from being exposed to diseases in polluted air. In other words, the air filter is an important agent for the delivery of clean air. Air filter perform as the prime defend to protect cooling and heating ventilation for vehicles air-conditioning system from dust and contaminant thus supply clean air to conditioned space. The air filter classifying is determined by the efficiency of particles removal. The higher efficiency of an air filter can improve indoor air quality that also given a good performance for equipment. The air filter efficiency is classified by the minimum efficiency reporting value (MERV) ratings as determined by a standard laboratory test outlined in ASHRAE Standard 52.2. The ASHRAE Standard 52.2 is make based on European standard that used EN 779 as the reference (Montgomery et al. 2012). The development a filter test rig and parameter take ISO has their standard guidelines. Besides that, the content of this standard will be the guide to complete this air filtration test.

Figure 1.1: K-chart of introduction
1.2 Problem Statement

Nowadays, cars are important because they provide a common means of transportation, whether it is a longer commute to work or a shorter trip to run errands around town. But there has a problem about VOC level inside the car that caused by passengers and driver itself. For example, smoking, petrol, paint and many more. Smoking inside small enclosed space such as a car particularly dangerous because smoke can accumulated rapidly (Murphy-Hoefer et al. 2014). The transportation account for approximately 20% of global energy consumption and the largest consumer of oil in the world. Petrol is the energy source that powers a variety of means of transportation and is used to power an internal combustion engine, but these fuels produce unpleasant odors for the passengers and the driver itself. Besides, the smell of paint on the car can also cause discomfort and this usually occurs on a new car. For all these sources leave a bad odor and producing low Indoor Air Quality (IAQ) inside the car.

1.3 Project Objectives

In this study, there are a few targets to be given full attention in order to achieve the objectives. The following below are objectives of this project.

1. To construct a VOC removal filter prototype to be install in Perodua Myvi 1.3cc car air conditioner.
2. To measure the decrease of level VOC before and after VOC removal filter installation by using 3M EVM Environmental Monitor Kit.
1.4 Scope

This research will focus on developing a prototype of the VOC removal filter for the car air-conditioning system. The Perodua Myvi 1.3cc car air filter has been selected for this project. The VOC removal filter will be installed at this car air conditioner without changing the shape of the original air filter that has been in it, and just put on top of or below the filter. The function of activated carbon or charcoal is to remove VOC inside the air. Therefore, air content in cars will be cleaner when there are two filters that have been installed on it. This can give comfort to the driver and passengers are in the car.
CHAPTER 2

LITERATURE REVIEW

2.0  Introduction

This chapter will focus on the theory and terms mainly related to this research, which is about how to develop of VOC removal filter for car air conditioner. This source of theory is from previous research and related articles. The aim of this chapter is to give better understanding about this research and give strong evidence, support, and the reasons why this research should be done. Lately, there is numerous studies have been related to the car air conditioner filter, therefore this study focusing on the new VOC removal filter and its efficiency to remove VOC contain inside air without affect indoor air quality. By referring to figure 2.0, the flow of this chapter is illustrated.

Figure 2.0: K-chart of literature review
2.1 Water filter

Water filter is a device for removing unwanted substances such as bacteria or harmful chemicals from drinking water. Water that has not been filtered, there are a many of bacteria and particles inside that can be harmful to human health. There are many type of water filter has been created by scientists to filter various impurities can be harmful to human health inside the water. Example of water filter is activated carbon filter, reverse osmosis, alkaline/water ionizer, UV filter and infrared filter. Activated carbon filters are commonly used during drinking water treatment for the removal of undesirable dissolved organic carbon (DOC) fractions including biodegradable organic matter, micro pollutants, halogenated hydrocarbon and taste and odor compounds (Velten et al. 2011). Reverse osmosis water filter or membrane is incredibly popular because it has the ability to remove all sorts of contaminants that can be a danger to human health, as well as make sure water is clear and odor free. Although the concept reverse osmosis (RO) has been known for many years, the use RO as a separation is a relatively young technology. The progress in RO is greatly depended on the development of RO membranes because its plays a key role and determines the technological and efficiency of reverse osmosis filter (Kang & Cao 2012). UV filter is one type of filter are possibly of the newest technology on the market. When ultraviolet radiation is used to treat water, it has ability to destroy various bacteria that can damage human health. This filter treat water by using UV lamp to remove a bacteria and no mineralization occurred through UV irradiation alone for 9 minute (Kim & Tanaka 2009). According to SU et al. (2009), the water filter tested in the present study showed good purification capability of removing the turbidity and total hardness inside water, through the whole filtration process in one life cycle. It has been reported that carbon water filter helps in the removal of organic compound from water, but cannot fully in removing microbial contaminants.
2.2 Electronic filter

Electronic filter is circuit which perform signal processing functions, it is specially to modify, reshape, and remove unwanted frequency components from signal (Storr 2014). Electronic filter can be passive or active. There are many electronic filter such as, digital filter, FFT filter, low-pass filter, audio filter and lagging phase filter. These types of electronic filter have their own function. Digital filter has two general purpose is to separation of signal that have been combined, and restoration of signal that have been distorted in some way (Smith 1997). Otherwise, digital filter has two signal use is signal separation and signal restoration. Signal separation is use when a signal has been contaminated with interference, noise or other signal and signal restoration is used when a signal has been distorted in some way, for example an audio is record with poor equipment will be filtered to better represent sound. FFT (fast Fourier transform) filter is a complicated algorithm and it a powerful tool to deal with the signal in the frequency domain. The frequency of input signal is analyzed by FFT filter and the required frequency components are selected (Jiao et al. 2015). Low-pass filter is a circuit offering easy passage to low frequency signal and passage to high frequency signals. This filter is design using operational amplifiers and low-pass filter are commonly used to implement antialias filter in data acquisition systems (Karki 2000).

2.3 Air filter

Air filters are used in applications where air quality is important, especially in building ventilation systems and in engines. Air filter is the important component that must have in HVAC system to protect cooling coils from dust, and thus prevent fouling. When talking about air filter indirectly indoor air quality also being considered because the air filter is an important part in providing a good indoor air quality (Edelman 2008). The air filter efficiency is classified by the minimum efficiency reporting value (MERV) ratings as determined by a standard laboratory test outlined in ASHRAE Standard 52.2.
The higher of efficiency of an air filter that improved indoor air quality provided. The good performance of equipment is related from good indoor air quality. Problems that always occur in HVAC systems especially odor pollution and air quality that is the air filter one of the causes.

2.3.1 Classification of air filter

The best filter design requires consideration of not only the lowest pressure drop but also the highest collection efficiency possible. To preview the performance of the air filter, several test produces must be carried out to prove the theory is the same as the experiment and test performed. These filters were classified with an ASHRAE Standard 52.2, MERV and the sample consisted of MERV 8, MERV 11, MERV 13, MERV 14 filters. It should be noted that River and Murphy conducted filter traverse tests in 1996 and thus did not necessarily do full test according to Standard 52.2 (Zaatari et al. 2014). If higher the rating of MERV is higher the efficient of the filter can catch more particles with small of size particles as shown in figure 2.1 and table 2.1. In addition to efficiency, filter attributes also include a reasonable holding capacity and suitable air flow for ventilation. Another factor must be considered air filtration becomes more efficient as their load, whereas electronic cleaning devices that need to be washed or rapidly lose efficiency as the plates that generate the electrostatic charge become coated with particles.

There are many types of air filter are always used in air conditioning and ventilation system. For the pre-filter usually uses a polyester or pleated filters, fiberglass filter, electrostatic filter and HEPA filter. The air filter plays significant role in air conditioning and ventilation system. Every ventilation system will need an air filter. For example, occupants need the air filters because of many environments that have been affected by airborne particle that cannot see using naked eye (William C. Hinds, 1999). The air we breathe usually contains large number of fine particles and chemicals. Estimates say that indoor air can contain millions of contaminant particles per liter. These
can give negative impact to human health, contributing to disorders and diseases at a growing rate, as shown by the increasing prevalence of problems such as asthma (Boni & Clark 2008).

Figure 2.1: The curve on the table above shows to the following applications (Camfil Farr 2013)

- 95% or MERV 14 – generally applied as the final filter in hospital HVAC system.
- 85% or MERV 13 – generally applied in above average commercial applications.
- 65% or MERV 11 – applied in standard commercial buildings, such as office space.
- 25% or MERV 6 and 7 – pleated panel filter, applied in office environments and pre-filters.
- < 20% or MERV 1 through 5 – typical polyester or fiberglass throwaway panels and washable filters.

Table 2.1: ASHRAE (MERV) Standard 52.2 (Ansi et al. 2014)
2.3.1.1 Fiberglass air filter

Fiberglass air filter is also known as “throw away” filter cause of the less expensive and have a shorter life cycle. In manufacturers, for this filter is suggest that be replaced every 30 days for maximum efficiency because fiberglass air filter is not designed to last very long and therefore are not very tough. But this fiberglass air filter is most effective particles captured on the filter surface may desorb into air passing through the filter (Bekö et al. 2009). The ability of fiberglass filter has been test in the laboratory on the basic of ASHRAE and European that shows this filter have great efficiency. High efficiency fiberglass filter has been in industry standard for air filtration applications. Fiberglass filter are made from flame attenuated glass fibers of about 1.0 – 1.3 mm in diameter (Vaughn & Ramachandran 2002) as shown in figure 2.2 below.

Figure 2.2: Disposable fiberglass
(Source: https://www.bobvila.com/articles/furnace-filter)
2.3.1.2 Polyester or pleated air filter

Pleated air filter is the most popular type of air filter for heating and air conditioning system. Besides that, pleated air filters are similar to fiberglass filters but typically have a higher resistance to airflow and a superior dust-stopping ability. This filter generally is the more popular choice because they are efficient but are not as expensive as another filter. Pleated filter is made from cotton, synthetic and polyester. The size of pleated filter is available in 1 inch, 2 inch, 4 inch and even 6 inch thickness. The classification for pleated filter according ASHRAE Standard 52.2 is MERV 8, this shows that pleated filter is suitable for applied at HVAC system. Typically, commercially available for pleated filters have two of pleat configuration, the rectangular shape and triangle shape (Chen et al. 2008). Figure 2.3 shown pleated air filter.

Figure 2.3: Polyester or pleated air filter
(http://www.airexco.net/merv-8-pleatedbr-2-inch-air-filter-c-108_91_95)