UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MONITORING DEVICE FOR HVAC AIR FILTER IN FILTER TEST RIG

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

by

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DECLARATION

I hereby, declared this report entitled “Development of monitoring device for HVAC air filter test rig” is the results of my own research except as cited in references.

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Date : 10/01/2017

APPROVAL

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:

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(Amir Abdullah Bin Muhamad Damanhuri)

ABSTRAK

Penapis udara merupakan komponen yang penting dalam sistem HVAC dimana ia bertujuan untuk mengelakkan bahan-bahan cemar seperti habuk, debu, dan asap dari menembusi dan memasuki sistem HVAC. Dengan tercemarnya udara tersebut ini secara tidak langsung akan memberi kesan kepada kesihatan manusia. Kajian ini akan dilakukan di stesen penapis udara. Kajian mengenai projek ini bertujuan untuk memantau dan mengambil data yang terhasil daripada udara yang akan melalui penapis udara tersebut. Ini bertepatan dengan objektif kajian ini iaitu membina sistem pemantauan kualiti udara di stesen penapis udara dan mengkaji kebolehpercayaan sistem pemantauan yang telah dibina. Skop untuk kajian ini dibahagikan kepada tiga bahagian. Bahagian yang pertama ialah parameter untuk sensor yang digunakan. Ia terdiri daripada sensor kelembapan dan suhu, debu dan aliran udara. Bahagian yang kedua ialah software dan hardware yang akan digunakan. Dalam kajian ini Arduino akan digunakan untuk software dan hardware. Bahagian yang terakhir pula ialah penapisan udara. Dalam kajian ini penapis udara yang akan digunakan ialah jenis pleated dan bag. Dari segi saiz, saiz yang digunakan adalah 24' x 24'. Kaedah kajian, yang dijalankan adalah dengan menggunakan proses carta aliran. Semua data akan diambil dan direkod di dalam jadual yang telah dibuat. Untuk data, ia mengambil kira dari sudut kelembapan, suhu, aliran udara dan ketumpatan debu. Di pengakhir kajian ini, ia menunjukan pengunaan Arduino adalah releven sebagai sistem pemantauan kualiti udara kerana keputusan yang diperoleh diantara peralatan di makmal dan projek sensor menunjukkan perbezeaan yang tidak ketara. Kajian ini menunjukkan semua objektif telah tercapai.

ABSTRACT

The air filter is an important component in HVAC system where it is intended to prevent contaminants such as mold, dust, and smoke from penetrating then entering HVAC system as it would circulate the air in the conditioning space. The contamination of the air will indirectly affect human health. The study are conducted in the air filter test rig. This project aims to monitor and collect data that will result from the air through the air filter. This is suitable with the objectives of this study, develop a sensor monitoring system to monitor the air filter performance and to examine the reliability of the sensor that has been develop. The scope of the study is divided into three parts. The first part is a parameter for the sensor used. It is consists of humidity and temperature sensors, particles and air flow. The second part is software and hardware that will be used. In this study Arduino will be used for the software and hardware. The last part was the air filtration. In this study, the air filter are used is pleated type and bag. In terms of size, the size is 24' x 24'. The research, carried out by using the process flow chart. All data will be collected and recorded in a table that has been formed. For the result, this study are taking data of humidity, temperature, air velocity and dust particles as the parameters in order to perform the data collecting. At the end of the study, it is showed that Arduino are suitable used as the sensor monitoring device where the data that has been collected with actual equipment and sensor project has a close their limitation value. Other than that, Arduino are chosen because it is use low cost sensor. All objective of this sensor are achieve which firstly is to develop a sensor monitoring device and secondly to examine the reliability of monitoring system that has been develop.

DEDICATION

Firstly I am very thankful to the Almighty Allah S.W.T because has giving me an effort to complete this project at the assigned time. I am very grateful in order to complete this project a crowded of friend and people are help me either directly or indirectly in effort. I am also wish a special thanks to my parents En Zakaria Bin Ab Rahim and Puan Saidah Bt Saad because always support me from behind.

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AC	- Air Conditioning
ASHRAE	- American Society of Heating Refrigerating and Air Conditioning Engineer
API	- Air Pollution Index
ACPU	- Air Cooled Package Unit
AVR	- Automatic Voltage Regulation
CFM	- Cubic Feet minute
COP	- Coefficient of Pump
DC	- Direct Current
DX	- Direct Expansion
GND	- Ground
HVAC	- Heating, Ventilation Air Conditioner
IDE	- Integrated Development Environment
LCD	- Liquid Crystal Display
MERV	- Minimum Efficiencies Rating Value
WCPU	- Water Cooled Package Unit
WSN	- Wireless Sensor Network
µm	- Micron meter

CHAPTER 1

INTRODUCTION

1.0 Introduction

The current chapter introduce the most important subtitle related to the present project. However, the subtitle are the strategy and the basic topics, which include background, problem statements, objective and the scope of the project and organization of the thesis.

1.1 Background study

The air filter is an important component in the HVAC system for being able to prevent contaminants from entering the air space and residential buildings. Contaminants are able to enter the air space either in the form of dust, gas and vapor. Air Filter viewed able to prevent and reduce air pollution levels in the building. Studies on the types of air filters, there are many who used nowadays but depending on the class of pollutants that need to removed. Typically, these contaminants will move from areas with higher air pressure to areas of low pressure. In the absence of air filters cause the movement of contaminants into the next will be easier to meet the air space of the building. Effects of these contaminants to humans is like cough, asthma, headaches and fatigue. However each person will react differently to these symptoms depending on the level of contaminants and antibody respectively. Therefore, it is important to build a system of sensors that can monitor the state of air filters that we use. With technology

today not only can simplify everyday human affairs but also can prevent unhealthy. This study was conducted to investigate the particular air filter will pair with sensor monitoring system.

1.2 Problem statements

Today, when people talk about air quality levels, they would have imagined it resulting from vehicle exhaust, open burning and pollution resulting from industrial areas. People believe that this is the main cause of things that contribute to air quality levels. However, they are supposed to concern residential areas to worry about than outside because 80 percent of the time we were in indoor area (Summit, 2016). Problems will arise if we fail to be concerned and well maintained air conditioning systems in our homes.

What happen if air filter that are using is out of the performance. According to study, beside it affect to the human health problem, the failure of air filter performance also cause the air conditioning system run in not good condition (Air, Munksgaard, & Issn, 2002). Firstly if air flow through the dirty duct it will cause the needed CFM are not achieve. This will make the system push more energy consumption in order to achieve thermal comfort. From relation of the problem it will make the system operate with high cost due to the energy that has been used (Montgomery, Green, Rogak, & Bartlett, 2012).

So, we really need the air filter as it is able to prevent us from continuing to breathe air that is not clean (Air & Government, 2013). However, even if we have installed air filters in air conditioning systems, sometimes health problems as described remain valid. This is how people still got sick even the air conditioning are used air filter. But we do not know how to determine the effectiveness of the air filter. So the study are conducted to enhance the effectiveness of air filters in the test rig system. At the end of the study it will review the data obtain from system monitoring device and an air filter.

1.3 Objective of the project

The objectives of this project will be divided into two parts:

a) To develop the sensor monitoring system to monitor the filter performance in the test rig.
b) To examine the reliability of monitoring system that has been develop.

1.4 Scope

Project scope is the part of project planning that involves determining and documenting a list of specific project goals, deliverables, tasks, costs and deadlines. The study was conduct at the air filter test rig. In order to perform the data collection there are several parameters that must be considered. There are the sensor that has been used, software and hardware, and air filtration. For sensor, it is including humidity and temperature, dust particles and airflow sensor. Meanwhile for the software and hardware, Arduino is used because it is including software and hardware. For the air filtration, it is used primary and secondary air filter where the type is pleated and bag. Dimension for this air filter is 24' x 24'.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The current chapter introduce the most important subtitle related to the present project. However, the subtitle are the strategy and the basic topics, which include background, problem statements, objective and the scope of the project and organization of the thesis.

2.2 Air conditioning system

The use of the air conditioning system is very important today not only to get comfortable and cool air but for other uses such as in the freezing industry, hospitality and tourism (Sublett, 2011). When people are mention the air conditioning system they would have imagined all the air conditioning system at home and in buildings such as in supermarkets, factories and others. In fact any system designed according to the requirements of the operating system such as air-conditioning system at home we use split units because the system was designed based on the size and capacity of the inside of a house (Feng, Long, & Chen, 2014). There are several types of air conditioning systems available such as window type, package air conditioners, central air conditioners and split air conditioner. All these types of systems have the same role, which is to produce and supply the clean air, ventilating, heating to the residence or workplace users.

There are four basic components in Air conditioning system, namely compressor, condenser, expansion valve and evaporator. Figure 2.1 below show the cycle of air conditioning system

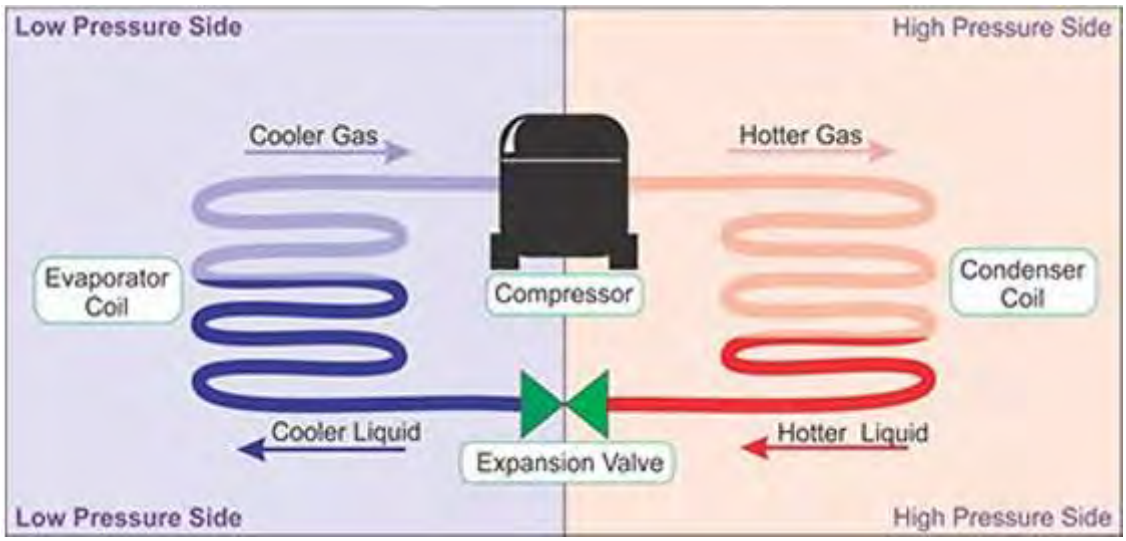

Figure 2.1 : The cycle of Air Conditioning System

1) Firstly, compressor will compressed the refrigerant that in vapor state. Refrigerant are at high pressure and temperature in vapor state. Then heat from refrigerant is transferred to the cooling fluid. Refrigerant condense to liquid.
2) Refrigerant is high temperature and high pressure but losses pressure when go through the expansion valve. Some refrigerant vaporize and absorb heat from refrigerant that doesn't vaporize. Refrigerant that have go through expansion valve then reduced their pressure.
3) Refrigerant absorb heat from warm air and reach low boiling point. Refrigerant vaporize and absorb maximum heat.
4) Low temperature and low pressure refrigerants enter compressor. A liquid at a high pressure is needed to achieve refrigerating effect.

2.3 Air quality monitoring system.

In previous years a lot of air quality monitoring system made mainly in European countries such as United State (US), Germany and the Netherlands due to higher air pollutant index (API) in several locations. The study was conducted due to a serious hazard to the public health as described such as heart diseases, stroke and lung cancer. In addition to trouble the public health problem of air pollution also affects the environment and the global economy (Yi et al., 2015). As we know air pollution problems will lead to the occurrence of acid rain. Acid rain is not only harmful to human health but also to the flora and fauna. According to the research conducted by (Anita Singh and Madhoolika Agrawal, 2006) titled "Acid rain and its ecological consequences", the phenomenon of acid rain has a bad effect on crops such as roots and leaves damaging the structure of plants, fruits to shrink and fall but also the effects of acid rain destroying the soil structure.

2.3.1 Air Pollutant Index (API) in Malaysia

In Malaysia, a studies on air quality monitoring systems aiming to measure air pollutant index and to formulate the set of air quality guidelines (Abas & Awang, 2015). The research has been made by Department of Environment (DOE), responsible for giving a guidance to the public on the status of air quality levels ranging from good to hazardous. To perform this API system the government has introduce their first standard Air Quality Index system known as Malaysia Air Quality Index (MAQI) in 1993. This standard has been introduced can be used for comparison to other countries as very similar to other standards such as Pollutant Standard Index (PSI) adopted in the country United States but since 1 April 2014 they include the particular matter (PM) in their standard.

Our country are following PSI in USA system because it is close with Malaysia standard. Therefore, the standard has been stated every API and a description of the level of air quality in a particular location. With the index reading, the government can take the necessary measures as a precaution and, if conditions are too severe air quality government can declare a state of emergency. Figure 2.2 below show the Malaysia's API that represent the level of air quality and color code. When there are occurs such condition the government will issued the directive and color code.

Malaysia's API		
Air Pollution Index (API)	Air Quality Category	Color Code
0 – 50	Good	
51 – 100	Moderate	
101 – 200	Unhealthy	
201 – 300	Very Unhealthy	
301+	Hazardous	

Figure 2.2 : Malaysia API reading

Source : Department of Environment Malaysia

To assess the level of air pollution, it is done by defining the study area to be done. This is because in each location is different API levels and generally the more developed regions have higher reading levels for example in urban areas(Abas & Awang, 2015). To perform a data collecting the sub-index values (sub-API) for all five air pollutants included in the API system are first calculated using the above mentioned sub-index functions for the air quality data collected from the continuous Air Quality Monitoring Stations. The following is an outline of the procedures involved in calculating the API values

(a) Collect continuous air quality data for the five air pollutants in the API system for sufficient averaging time periods.

(b) Conduct the necessary calibration, validation, quality control and quality assurance in the process of data collection.

(c) Calculate average concentration of the specific air pollutants for the specified average time periods.

(d) Calculate sub-index value for each of the five air pollutants based on the average concentrations calculated and with the use of the sub-index functions

(e) Report the API at a given time for the preceding averaging period (taking the common end point of l-hour, 8-hour or 24-hour for all have pollutants) in terms of the highest sub-index value obtained.

API = Max {sub-indices of all five air pollutants}

Table 2.1 : Recommended Malaysia Air quality guidelines

adopted in Air Pollutant Index calculation.

Source : Department of Environment Malaysia(DOE), 2000

Bahan Pencemar / Pollutant	Masa Purata / Averaging Time	Garis Panduan Malaysia / Malaysia Guidelines	
		ppm	(μg/m³)
Ozon / Ozone	1 Hour	0.10	200
	8 Hours	0.06	120
Karbon Monoksida / Carbon Monoxide	1 Hour	30.0	35**
	8 Hours	9.0	10**
Nitrogen Dioksida / Nitrogen Dioxide	1 Hour	0.17	320
	24 hours	0.04	
Sulfur Dioksida / Sulphur Dioxide	1 hour	0.13	350
	24 Hours	0.04	105
Pepejal Terampai (PM_{10}) / Particulate Matter (PM_{10})	24 Hours		150
	12 Months		50
Jumlah Pepejal Terampai / Total Suspended Particulate (TSP)	24 Hours		260
	12 Months		90
Plumbum / Lead	3 Months		1.5

As shown in table 2.1 above, Malaysia has been introduce the recommended guidelines for Air Pollutant Index calculation. This is intend to facilitate the data that has been collecting. As the data explain above there are different type of pollutant that recorded in this country.

Table 2.2 : The comparisons of API values with level of pollutions and health measured.
Source : Development of Environment Malaysia

API	Status	Level of Pollution	Health Measure
0-50	Good	Pollution low and has no ill effect to human health.	No restriction of activities for all groups of people.
51-100	Moderate	Moderate pollution and has no ill effect on health.	No restriction of activities for all groups of People.
101-200	Unhealthy	Mild aggravation of symptoms among high risk person, e.g. with heart or lung diseases.	Restriction of outdoor activities among high risk persons, e.g. for high risk persons
201-300	Very unhealthy	Significant aggravation of symptoms and decreases of exercise tolerance in person with heart or lung diseases.	Elderly and person with known heart and lung diseases should stay indoors and reduce physical activity.
301-500	Hazardous	Severe aggravation of symptoms and endangered health.	Elderly and person with existing heart and lung diseases should stay indoors and reduce physical activity.
Above 500	Emergency	Severe aggravation of symptoms and endangered health.	General population advised to follow the

			orders to the National Security Council and always to follow the announcements through the mass media

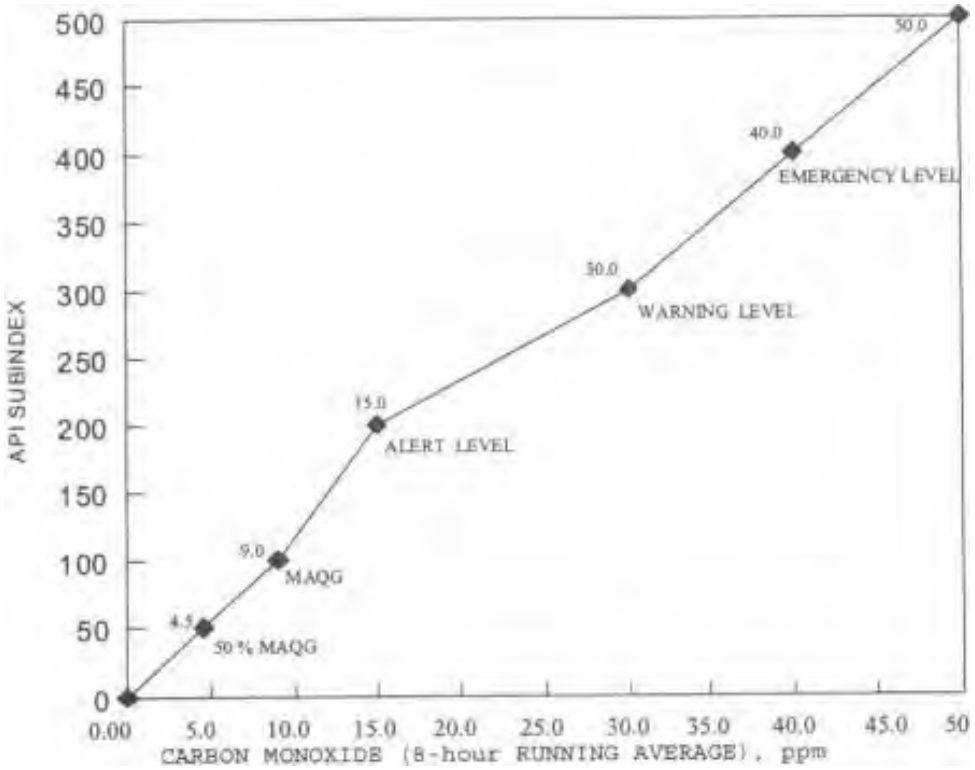

Figure 2.3 : API subindex function for carbon monoxide

As shown in table 2.2 and figure 2.3, it can be concluded that the result is directly proportional with API Subindex and particles data. Each phase show what effect