UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SOUND AND VIBRATION ANALYSIS OF PORTABLE AIR-CONDITIONING SYSTEM USING PELTIER MODULE AS POWER SOURCE

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

by

MUHAMAD HILLMI NADIM BIN AZMAN

B071610868

930913-08-5055

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

2019

© Universiti Teknikal Malaysia Melaka

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Sound And Vibration Analysis Of Portable Air Conditioning System Using Peltier Module As Power Source

SESI PENGAJIAN: **2019/20 Semester 1**

Saya **MUHAMAD HILLMI NADIM BIN AZMAN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☒ TIDAK TERHAD

Disahkan oleh:

Muhamad Hillmi Nadim Bin Azman

Alamat Tetap:

No. 5, Persiaran Puncak Iskandar

2A/4, Puncak Iskandar, 32610 Seri

Iskandar, Perak.

Tarikh: _____

Nor Azazi Bin Ngatiman

Cop Rasmi:

Tarikh : _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

© Universiti Teknikal Malaysia Melaka

DECLARATION

I hereby declared this report entitled “Sound And Vibration Analysis Of Portable Air-Conditioning System Using Peltier Module As Power Source” is the results of my own research except as cited in references.

Signature : .....

Name : Muhamad Hillmi Nadim Bin Azman

Date : 27 December 2019

© Universiti Teknikal Malaysia Melaka

APPROVAL

This report is submitted to the Faculty of Mechanical And Manufacturing Engineering Technology of UTeM as a partial fulfilment 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:

Signature	:	.....
Supervisor Name	:	Nor Azazi Bin Ngatiman
Date	:	.....

© Universiti Teknikal Malaysia Melaka

ABSTRACT

This report is about Sound And Vibration Analysis Of Portable Air-Conditioning System Using Peltier Module As Power Source. Usually, unlike other places that has heavy work activities, cooling load of small private office room is low due to its limited space. It is a big waste to use a compressor-based unit air conditioning in this small area in terms of power consumption and cost. So, the usage of small portable air-conditioning is recommended. The small portable air-conditioning system by using Peltier effect module is subjected to control the comfort level by removing the sensible and latent heat inside the space. Peltier is thermoelectric semiconductor that provides cool and hot plate after electric is supply to the plate. The cool side use to reduce temperature and the hot side is treat in the system. Besides that, the development of this product should consider the noise outcome from the product while its operating because noise level is also one of element to ensure comfortness to the consumer. This is to analyse how product sound level (Primary Sound) would give effect to private office room sound level (Background Sound) and also analyse the vibrations level that emitted from each parts inside product by using suitable measurements instruments to generate statistical analysis for both sound and vibrations level of product that contribute to overall noise level of product. Sound level of product when put inside private office room was measure using Sound Level Meter and the result is when compared to the standard range of sound level in private office room (50 dB), product average sound level did have a little increment which is 68.7 dB. But this result still in safe range of noise level because according to sound level standard range, sound level below 85 dB is consider as in safe range. To prove the result of product sound level, same method of measuring was use and product was measure in acoustic room and the average sound level result obtain was nearly same as in private office room which is 62.4 dB. For vibrations level, each components inside product that produce vibrations was measure using Accelerometer to obtain signal waveform in Time Domain and Frequency Domain. Based on value and patterns of Time Domain and Frequency Domain waveform, components that lead to higher vibration amplitudes was Water Pump.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Laporan ini adalah mengenai Analisis Bunyi Dan Getaran Sistem Penyaman Udara Mudah Alih Menggunakan Modul Peltier Sebagai Sumber Kuasa. Biasanya, tidak seperti tempat-tempat lain yang mempunyai aktiviti kerja yang berat, beban penyejukan bilik pejabat swasta kecil adalah rendah disebabkan ruang yang terhad. Ia adalah sisa besar untuk menggunakan penyaman udara unit pemampat di kawasan kecil ini dari segi penggunaan kuasa dan kos. Oleh itu, penggunaan penghawa dingin mudah alih kecil adalah disyorkan. Sistem penghawa dingin mudah alih kecil dengan menggunakan modul kesan Peltier tertakluk untuk mengawal tahap keselesaan dengan mengeluarkan haba yang masuk akal dan terpendam di dalam ruang. Peltier adalah semikonduktor termoelektrik yang menyediakan plat sejuk dan panas selepas bekalan elektrik ke plat. Penggunaan sisi sejuk untuk mengurangkan suhu dan bahagian panas merawat dalam sistem. Di samping itu, pembangunan produk ini harus mempertimbangkan hasil bunyi dari produk semasa operasi kerana tahap bunyi juga merupakan elemen untuk memastikan keselesaan pengguna. Ini adalah untuk menganalisis bagaimana tahap bunyi produk (Bunyi Primer) akan memberi kesan kepada tahap bunyi bilik pejabat peribadi (Latar Belakang) dan juga menganalisis tahap getaran yang dikeluarkan dari setiap bahagian di dalam produk dengan menggunakan instrumen ukuran yang sesuai untuk menghasilkan analisis statistik untuk kedua-dua bunyi dan tahap getaran produk yang menyumbang kepada tahap bunyi bising keseluruhan produk. Tahap bunyi produk apabila dimasukkan ke dalam bilik pejabat swasta diukur menggunakan 'Sound Level Meter' dan hasilnya adalah apabila dibandingkan dengan tahap piawai tahap bunyi di bilik pejabat swasta (50 dB), tahap bunyi purata produk mempunyai sedikit kenaikan iaitu 68.7 dB. Tetapi hasil ini masih dalam tahap bunyi bising yang selamat kerana menurut julat piawai tahap bunyi, tahap bunyi di bawah 85 dB dianggap dalam julat selamat. Untuk membuktikan hasil tahap bunyi produk, kaedah pengukuran yang sama digunakan dan produk diukur di bilik akustik dan memperoleh keputusan tahap bunyi purata hampir sama seperti di ruangan pejabat swasta iaitu 62.4 dB. Untuk tahap getaran, setiap komponen di dalam produk yang menghasilkan getaran adalah diukur menggunakan 'Accelerometer' untuk mendapatkan bentuk gelombang isyarat dalam Domain Masa dan Domain Frekuensi. Berdasarkan nilai dan corak gelombang isyarat Domain Masa dan Domain Frekuensi, komponen yang membawa kepada amplitud getaran yang tinggi ialah Pam Air.

© Universiti Teknikal Malaysia Melaka

DEDICATION

This project and research work are dedicated to my precious parents, Azman Bin Abu Hassan and Norsalasani Binti Abd Rahman for their love and sacrifice throughout my life. Their sacrifice had inspired me from the day I learned how to read, write and until what I have become now.

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

First of all, all praise to Allah the Almighty for giving me the strength, health and patience to working on this project. I would like to express my gratitude to my supervisor, Nor Azazi Bin Ngatiman for his supervision and guidance that have guided me. Futhermore, I would like to thanks my beloved parents for their unstop support throughout the entire life. Finally, thanks a lot to everyone that directly and indirectly involved in helping me regarding this project. Thank you so much.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENTS

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

CHAPTER 5 : CONCLUSION AND RECOMMENDATIONS

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.0 Background

In human life, the thermal comfort zone is one of the important requirement to ensure a better lifestyle so our physical and mental sensation is always in a comfortable condition. To provide thermal comfort zone, hot temperature from a space must be evacuated. The conventional unit like split unit looks like not economical to be used in private office area that commonly are more smaller size than normal office size because much energy will be waste, extra cooling effect and the usage of refrigerant for small working area are not economic to its environmental. For private office, commonly it contains light occupant so to remove the low cooling load it requires less energy. Another requirement in human life that is important to care is our surrounding noise level. In daily life, constant noise that happen in space can lead to the raise of stress level and it plays a large part in human productivity. When an occupant in private office need concentration in a task, the effect of any noise will effect their productivity of work. A previous research (Saifulzaman, 2018) has developed a portable air conditioner that fully utilized both cool and hot side peltier effects to overcome the wastage of energy consumptions. But there are no sound and vibration analysis to analyse the outcome level of noise from the portable air conditioning that may disturb human hearing sense or may not suitable to be use in private office room in terms of its level of noise emitted.

© Universiti Teknikal Malaysia Melaka

1.1 Problem Statement

Stay in comfort when in an area that has air conditioner is a must for every user. Users definitely prefer minimum low noise from air conditioner as much as possible to avoid hearing disturbing. A frequent problem of the air conditioner is the noises that produce from sound and vibration of air conditioner. Noise is considered undesirable and it is necessary to find a way to analyse its level. To achieve the target, this research will redesign a new portable air conditioner by using peltier effects and identify its level of sound and vibration whether its level is acceptable for human hearing comfort or not.

1.2 Objectives

This project aims to develop a Portable Air Conditioning System by Peltier Module, then analyse the noise level that come from sound and vibration of the design product. There are several objectives to achieve the aims :

1) To develop portable air conditioning by using peltier as power source.
2) To analyse sound and vibration generated from portable air conditioning using statistical analysis.
3) To compare the sound level in private office room without the existence of portable aircond and after the existence of portable aircond.

1.3 Scope

There are several unavoidable limitations in this project. First, this sound and vibration analysis only limit for normal human comfort hearing sense which is below 60 db and for one occupant only due to the usage of this product is suitable for one occupant. Second, the selected room for this noise level analysis is a private office or restricted area that has light activity.

© Universiti Teknikal Malaysia Melaka

Third, due to the size of this project is small and it is portable, the amount of energy use for this project is limited.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter is to identify more about why the outcome level of sound and vibration on Portable Air Conditioning System in private office should be analysed. It also discussing the relevance of this project to avoid problems and provide better research in Portable Air Conditioning System by using Peltier Module in private office room.

2.1 Thermal Comfort

A person's thermal comfort state has an intimate relationship with himself physically and mentally. In our life, many factors influenced thermal comfort. For example the air movement in space, moisture content in air, air temperature, individuals choice in clothing, amount of activity level done by occupants in a space that can effect the metabolic rate and solar infiltration. Based on psychrometric chart at Figure 2.1, the green space is the comfort zone area which is thermal comfort is achieved there. Thermal comfort is influenced by many factors, such as thermal surroundings (temperature, humidity, radiation flux, air flow), human activities, clothing, and perception of how hot an area is. It is not simply the complexity and methodological differences observed in the related literature that make any comparison with available results difficult to assess comfort outdoors. Comfort can generally be assessed through indices of comfort. The literature contains a large number of indices, including predicted mean vote, thermal stress index, perceived temperature,operating temperature, standard effective temperature, mean radiant temperature, and physiological equivalent temperature.(Hui Li, 2016).

© Universiti Teknikal Malaysia Melaka

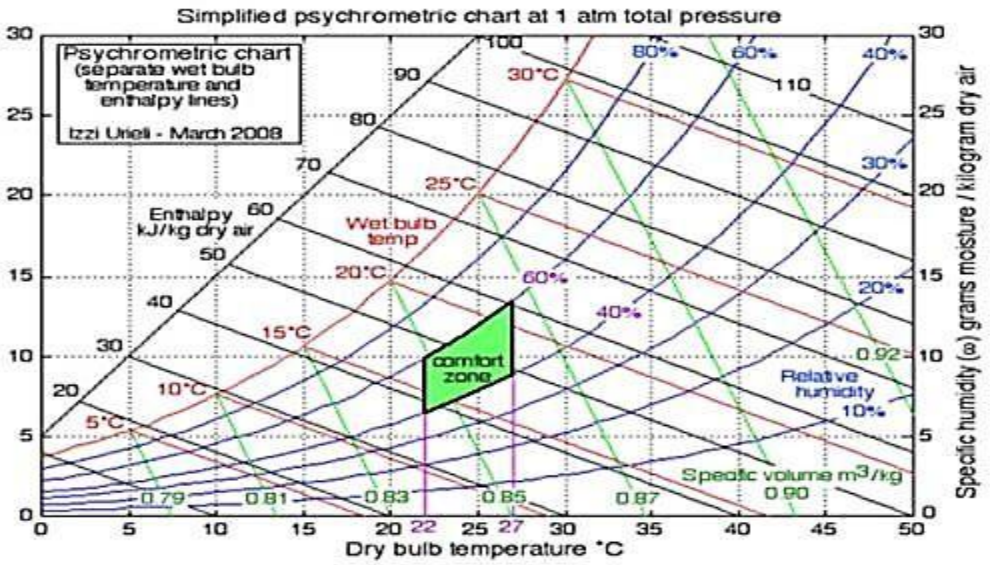

Figure 2.1 : Psychrometric chart of comfort zone (ASHRAE, 2009)

Table 2.1 shows in average for up to 8 hours per day, that is the acceptable range of each parameter for thermal comfort. These factors include the need for real life user guidelines to achieve the best thermal comfort for people in a building.

Table 2.1 : Acceptable range of parameter in average for up to 8 hours/day

Parameter	**Acceptable range (TWA)**
Temperature (°C)	22 – 27
Relative humidity (%)	40-70
Air velocity (m/s)	0.15-0.50

*TWA= time-weighted average for up to 8 hours/day

2.2 Cooling load

Cooling load is the rate at which insistence must be evacuated from a space to keep up the temperature and moistness at the arrange regards. Figure 2.2 shows there is five sources of heat generate which is from sun situated radiation, heat conduction, heat convection, ventilation, and filtration air.

© Universiti Teknikal Malaysia Melaka

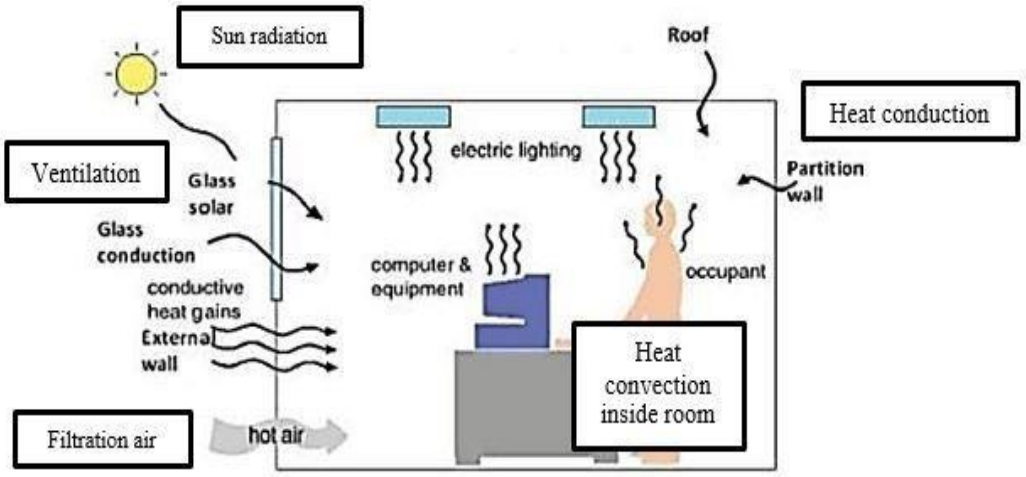

Figure 2.2 : Various type of cooling load sources in an office

Figure 2.2 shows the cooling load component including external load (e.g.; heat gain through exterior walls & roof, infiltration of outdoor air) and internal load (e.g.; occupants, electric lights, equipment, and appliances). For a person to feel comfortable in a cubical office, cool air needs to be distributed directly to a person at range 1-1.5 meter surrounding an occupant that will limit the consumption energy use air hence will lower the energy consumptions. In fact, air-conditioning represented around 90% of the total private section utilization (Wong, Wan and Lam, 2010).

2.2.1 Cooling Load Calculation

There are many type of method to calculate cooling load such as rule of thumb, cooling load temperature different (CLTD) and software. It is important to do the calculation of cooling load because its help in selecting the suitable system to be installed to remove heat efficiently. The building cooling loads computed by simulation based on local weather data can form a good basis for plant sizing (Li, Wong, & Lam, 2003). Rule of thumb is the easiest way to find cooling load but not accurate as other method. Hence, rule of thumb is use in common to predict the cooling

© Universiti Teknikal Malaysia Melaka

load of space. The calculation is only need area of selected space to calculate the cooling load.

Applications	Occupancy Sq Ft / Person			Lighting Watts / Sq Ft			Fresh CFM / Person			Air CFM / Sq Ft			Room Sensible Btuh / Sq Ft			Room Total Btuh / Sq Ft			Grand Total Btuh / Sq Ft			Refrigeration Sq Ft / Ton*			Supply Air CFM / Sq Ft		
	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi
Apartments (Flats)	150	100	50	1.0	2.0	4.0	25	35	40	.25	.35	.50	15	25	45	20	30	50	30	40	60	400	300	200	.75	1.25	1.75
Auditoriums, Theaters	15	10	5	1.0	2.0	3.0	5.0	15	30	.50	1.5	2.5	25	35	50	45	55	70	60	80	120	200	150	100	1.25	1.5	2.5
Educational Facilities																											
Classrooms	30	25	20	2.0	4.0	6.0	5.0	7.5	10	.20	.30	.40	25	40	55	35	50	65	45	60	80	275	200	150	1.0	1.4	1.8
Laboratories	75	60	40	2.0	3.0	6.0	10	15	20	.20	.40	.60	30	40	55	35	45	65	45	60	75	275	200	150	1.0	1.4	1.8
Cafeteria-Coffee House	20	15	10	1.5	3.0	4.5	7.5	10	15	.40	.60	.80	25	45	65	35	60	75	55	80	110	225	150	110	1.0	1.5	2.1
Factories	50	35	25	3.0	4.5	6.0	5.0	10	15	.10	.25	.50	20	45	75	30	60	85	50	80	130	240	150	90	1.0	2.25	3.0
Public Areas	200	150	100	9.0‡	10.0‡	12.0‡	5.0	10	15	.05	.10	.15	35	55	75	40	60	80	80	80	120	200	150	100	1.5	2.75	3.0
Light Manufacturing	300	250	200	15.0‡	45.0‡	60.0‡	5.0	10	15	.03	.08	.10	75	115	155	80	120	160	120	150	200	100	80	60	3.0	4.0	6.5
Heavy Manufacturing**	20	15	10	1.0	1.5	2.0	5.0	10	15	.50	.75	1.0	30	35	50	40	50	70	60	85	120	200	150	100	1.0	1.1	1.4
Hospitals																											
Patient Rooms†	100	60	40	1.0	2.0	3.0	75	90	100	.75	1.6	2.5	15	35	50	20	40	55	80	120	165	200	100	75	.75	1.2	1.7
Public Areas	130	100	65	2.0	3.0	4.0	10	20	30	.25	.75	1.5	10	15	35	15	20	40	30	45	100	400	275	120	.75	1.2	1.7
Laboratories	150	100	50	2.0	5.0	10.0	20	30	50	.20	.50	1.0	25	45	60	30	55	70	45	70	100	275	175	120	1.0	1.5	2.0
Libraries	150	100	50	2.0	4.0	6.0	5.0	7.5	10	.10	.20	.30	20	30	50	25	35	55	30	45	70	400	275	175	1.0	1.1	1.7
Doctors Clinics	150	100	50	2.0	4.0	6.0	20	25	30	.25	.40	.60	20	40	60	25	45	65	40	60	80	300	200	150	1.0	1.4	2.0
Offices																											
Private	150	125	100	4.0	6.0	8.0	20	25	30	.25	.40	.60	25	50	75	30	55	80	40	75	90	300	175	135	1.0	1.7	2.4
General-Perimeter	125	100	75	4.0	6.0	8.0	10	15	20	.15	.25	.40	20	35	70	25	40	75	30	50	85	400	250	150	1.0	1.2	2.3
General-Interior	125	100	75	4.0	6.0	8.0	10	15	20	.15	.25	.40	15	20	30	20	25	35	25	30	40	475	400	300	.75	1.0	1.1
Conference Rooms	45	30	15	4.0	6.0	8.0	20	30	50	.40	1.0	1.5	30	55	80	40	65	90	60	85	120	200	150	100	1.0	1.8	2.7
Restaurants	25	20	15	1.5	1.7	2.0	10	15	20	.50	.75	1.0	30	35	50	40	50	70	60	85	120	200	150	100	1.25	1.5	2.0
Shopping Centers																											
Beauty & Barber Shops	45	40	25	3.0‡	5.0‡	9.0‡	7.5	15	20	.20	.50	1.0	25	35	55	30	40	60	50	60	80	250	200	150	1.25	1.5	2.0
Department Stores -Basement	40	30	20	3.0	4.0	5.0	5.0	7.5	10	.10	.20	.25	20	30	45	25	35	50	35	45	60	325	275	200	1.0	1.4	1.75
-Main Floor	40	25	20	4.0	6.0‡	9.0‡	5.0	7.5	10	.15	.25	.35	25	35	45	30	40	50	40	50	60	300	250	200	1.0	1.5	2.0
-Upper Floors	80	50	40	2.0	4.0	6.0‡	5.0	5.0	7.5	.05	.10	.15	15	25	35	20	30	40	30	40	50	400	300	250	.80	1.0	1.2
	40	30	25	2.0	3.0	4.0	10	15	20	.25	.35	.50	30	35	45	40	45	55	60	65	75	200	180	160	1.25	1.5	2.0
	40	25	20	3.0	4.0	6.0	5.0	7.5	10	.15	.25	.35	25	35	45	30	40	50	40	50	60	300	250	200	1.0	1.4	2.0
	60	40	30	1.0	1.5	2.0	5.0	7.5	10	.10	.20	.30	10	15	25	15	20	30	25	30	40	500	400	300	.75	1.2	1.5
Specialty Shops	60	50	40	2.0	3.0	4.0	5.0	7.5	10	.10	.20	.30	25	35	45	30	40	50	40	50	60	300	250	200	1.2	1.4	2.0

Figure 2.3 : Design and cooling load check figure (ASHRAE,2014)

© Universiti Teknikal Malaysia Melaka

2.3 Normal Offices Cooling Environment

Office is a place where a business is run by a company. A company may have only one office, known as their home office, a head office, a variety or branch offices. All these offices are involved in the business of the company in some way. Keeping each staff cool in all wheather conditions is a one way to keep them motivated to provide the best working quality and create a comfortable working environment to work as a team. There's nothing worse than going into a hot and sweaty office working area. When installing air conditioners in an office, there are a number of factors that need to be considered. The type and specifications of air conditioners to be install must properly selected and fully consider the shape and layout of the office to be cooled because to avoid the workspace receiving much air flow than its needed and avoid energy wasted to occur. It is not uncommon to find that half an office is too cold while the other half is too hot with a poorly designed system, which can cause office temperature disagreements.

2.4 Private Office

Private office is a small room separated by partitions from the open office. Sometimes, private office is own by a people who are doing special project, performing confidential nature of work or need extra concentration in work. To create a great concentration of mind possible, usually private office provide better ventilation, heating and cooling, and absence of any noise to gives space for improvement of efficiency.

2.4.1 Private Office Cooling Load

Due to the area and volume of space give affected in cooling load, private office cooling load is not as much as factory and larger space. The larger the space, the larger the area that exposes to the sunlight and also higher chances of external

© Universiti Teknikal Malaysia Melaka

loading into the space. The private office occupancy is 150 ft²/person based on the thumb table rule, the lighting watt is 4 watt/ft2 and the sensitive room is 25 btuh/ft². It shows that the cooling load of office is possible to determine by depending on the size of office. The office cooling load is small and requires a small system to remove sensible and latent heat within the office from 3000 btu/hr to 5000 btu/hr (SAHU, 2014).

2.4.2 HVAC system commonly used in private office

Portable air conditioners are commonly used for the cooling of a single room and are great tools to support a central air system. Most of them are easily set up due to their one unit system. A portable air conditioning entire point is to discharge hot air during cooling. Because of this, these units need a way to throw that warm air to somewhere else. The most common way that these air conditioners use are vented it through an outside window, but some models may be exhausted through a drop ceiling or a wall.

2.5 Differences between Split Unit and Portable Air Conditioning Unit

Figure 2.4 and Figure 2.5 is the image of Split Unit and Portable Air Conditioning Unit which is each type have their own characteristics and different specifications. The purpose of it is to differentiate and determine which unit is the most convenient in terms of system efficiency, power consumptions, initial cost and space/noise.

© Universiti Teknikal Malaysia Melaka