UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE ANALYSIS OF PERSONAL AIR-CONDITIONING SYSTEM USING EVAPOLAR AS HEAT WASTE MANAGEMENT

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

ABDUL QAIYUM BIN MOHD SHARIFF

B071610961

940614055023

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

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TAMAN PINGGIRAN SENAWANG
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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 partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Refrigeration and Air Conditioning Systems) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Negara iklim tropika, terutamanya di Malaysia adalah dikelaskan sebagai suhu tinggi dan dan fenomena ini menentang keselesaan haba manusia dalam bangunan. Umumnya, bilik pejabat peribadi kecil mempunyai beban pendinginan yang rendah berbanding dengan tempat lain dengan aktiviti kerja berat. Penggunaan kuasa tinggi dan kos permulaan untuk unit berasaskan pemampat yang digunakan di dalam bilik kecil adalah besar dan bukannya menggunakan penghawa dingin mudah alih kecil. Sistem penghawa dingin peribadi kecil dengan menggunakan modul Peltier tertakluk untuk mengawal tahap keselesaan dengan mengeluarkan haba yang sesuai di dalam bilik. Modul Peltier adalah semikonduktor termoelektrik yang menyediakan plat sejuk dan panas selepas bekalan elektrik ke plat mempunyai keupayaan yang berbeza dan projek ini menunjukkan bahawa sambungan litar secara selari dapat meningkatkan keupayaan Peltier tersebut. Projek ini dapat mengurangkan penggunaan kuasa, kos dan menyediakan zon selesa terma di kawasan khusus. Manfaat projek ini dapat mengurangkan kos dengan mengurangkan penggunaan kuasa dan juga peranti teknologi hijau kerana tidak menggunakan bahan pendingin yang dapat membahayakan dunia. Dengan mereka semula produk dan meggunakan Evapolar sebagai pengurusan haba buangan, prestasi produk ini hendaklah dikira. Produk ini ditumpukan kepada penggunaan ruang pejabat. Produk ini menggunakan udara untuk membuang haba dan data menujukkan ianya berupaya dalam membuang udara tanpa adanya pengawalan suhu. Keupayaan produk tanpa pengawalan suhu menunjukkan ianya mampu beri keselesaan kepada pengguna.

ABSTRACT

In this tropical climate state, particularly in Malaysia, it is classified by elevated temperature and this phenomenon resists human heat comfort in building compared to other places with massive job operations, small private office space usually has a low cooling load. High energy usage and initiating price for compressor-based units used in tiny rooms is a massive waste instead of using little mobile air conditioning. Using the Peltier impact module, the small private air-conditioning scheme is exposed to regulate the amount of convenience by reducing sensible and latent heat inside the room. Peltier module or thermoelectric module is a thermoelectric semiconductor that provides cooling and hot plate after electric is supply to the plate, whereas Peltier has different performance and this project proves that with a series circuit, performance of Peltier higher compared to the previous researcher. This project's ability to reduce the power consumption, cost and provide thermal comfort zone in a dedicated area. The benefit of this project can cut the cost by reducing power consumption and also green technology devices because of not using a refrigerant that can harm the world. By redesigning this product and using Evapolar as heat waste management, the performance of the product needs to be calculated. Process preparation of this product is different compared to a previous product which it's smaller, less heavy, and portable to bring anywhere. This product focusing on the office room, which gives comfort to occupants. This product uses air to remove the heat waste and data shows Evapolar is efficient enough in removing heat. Performance for this product without a controller of temperature shows that it can achieve thermal comfort level.

DEDICATION

This project and research work are dedicated to my family and the memory of my mother.

ACKNOWLEDGMENTS

First of all, all praise to Allah the Almighty for giving me the strength, health and patience to complete this project. Enormous gratitude my beloved parents and sister for their unstop support throughout the entire life. For more, I would like to express my appreciation to my supervisor Mr. Mohd Farid Bin Ismail and Mr. Nor Azazi Bin Ngatiman for their supervision and guidance that have guided me in accomplishing this project. Besides that, I am grateful for having my helpful friends as my companion along the way while working on this project. Finally, thanks a lot to everyone that directly and indirectly involved in helping me to finish this project successfully.

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LIST OF SYMBOLS AND ABBREVIATIONS

ASHRAE	-	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
HVAC	-	Heating, Ventilating and Air Conditioning
AC	-	Air Conditioning System
COP	-	Coefficient of Performance

CHAPTER 1

INTRODUCTION

1.0 Background

The cooling unit to cool a room usually using a split unit which is larger amount of cool air to distribute. For example, standard office with area 12'x12' will be a waste to cool the whole room since the space that needed is a small area. In-office buildings, occupants will have to restrict space to move and have to control their movements. It will give an uncomfortable zone due to unbalanced comfort ventilation. (S. Karjalainen, 2009). This shows that a portable air conditioner can cool in the range of 1 meter around a person will be more suitable than split units since it conserves less energy. Hot temperatures in a space must be removed to achieve thermal comfort zone.

The previous researcher (Shahril, 2017) found that the Peltier module can cool down temperature and develop it as a portable air conditioner. It's also proven to overcome waste energy consumption in Portable Air Conditioning, Peltier Module was used. Hot effects on the hot side of the Peltier Module cannot fully be utilized while vice versa on the cold sides. The problem with the hot sides that not be used in Peltier Module must be utilized because Portable Air Conditioning using Peltier Module have a great accomplishment in transfer cool air to surroundings. Peltier Module will be affected due to a lot of heat waste to the surroundings. The latest researcher (Raidhah, 2018) found that heat waste from portable air conditioning using a Peltier module can be used as heat energy. Heat recovery can be proven for integrating hot water dispenser using Peltier effects. This project also showed that thermal efficiency in the heat recovery process proves that higher thermal conductivity

produces higher heat transfer to the surface. Less amount of heat loss happened during the project completed.

To achieve Thermodynamics Law, where energy cannot be destroyed or change to another form, this research will design a new product in managing the heat waste from the Peltier effect.

1.1 Problem Statement

From the latest product of portable air conditioning system design by (Raidhah, 2018), the heat waste release to the surrounding in large amounts due to unorganized energy. The thermal comfort zone that standardized by the (ASHRAE, 2014) is around 22^{O}C to 24 ^{O}C for most buildings in Malaysia. Heat waste from the Peltier module spread to the air and cause uncomfortable to users. Due to limited space in a room, users feel hotter because of Peltier Module generates the same capacity of hot and cold energy. Adding with external energy such as electrical equipment and body, the temperature increase and hot temperature will overwhelm cold temperature. So in favor of producing thermal comfort zones, this research will design new ways on how to recover the heat waste from release to surroundings. In terms of ergonomics to users, this product needs to be upgraded for a better purpose. The heat waste from the product needs to be recovered to ensure the product will be convenient and increase efficiency. This method also is a new idea in managing heat waste using Evapolar and finding ways to increase the effectiveness of the system.

1.2 Objectives

The aim of this project is to redesign and to upgrade the previous product of a portable air conditioning system by the heat recovery process using Peltier Module. The heat recovery process will ensure to spread the heat into outer space to provide thermal comfort to the user. There are several objectives to achieve the aims:

1. To redesign Portable Air Conditioning System using Peltier Module.
2. To fabricate the Portable Air Conditioning System using Peltier Module according to the selected design.
3. To test the product performance by using Evapolar as heat waste management

1.3 Scope

The scope of study in this project.

1. Focusing on the ability to managing the heat waste generated from Peltier Module.
2. The medium of heat transfer is through the water as a cooling source.
3. The heat recovery system using the Evapolar mechanism.
4. The selected area for this research is a standard office room, have light activity and limited electric equipment.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter discusses further the process development of heat waste management by using various types of methods. Besides that, it resolves to analyze and find the most suitable ways of finding the best options in waste heat management. This chapter is also discussing the relevance of the project to avoid problems and provide better research in a portable air conditioning system using Peltier Module.

2.1 K-Chart

By using K-Chart as shown in figure 2.1, planning and monitoring all activities can be done systematically through the preparations. Inadequate research or planning leads to inefficient resources and too much cost will be spent. First of all, to ensure this research can be done, thermal comfort conditions must be known. Then, loads of capacity can investigate either using heating load or cooling load. The suitable load must be chosen to provide a thermal comfort suitable AC system in the office. There are several types of AC systems used in an office, but to focus on low consumption of energy and provide comfort for a person, portable AC is used. Source of energy use is Peltier which different from other sources. Peltier generates hot sides that need to be treated using Evapolar and heat sink is used as a medium in treats heat to achieve COP for this system.

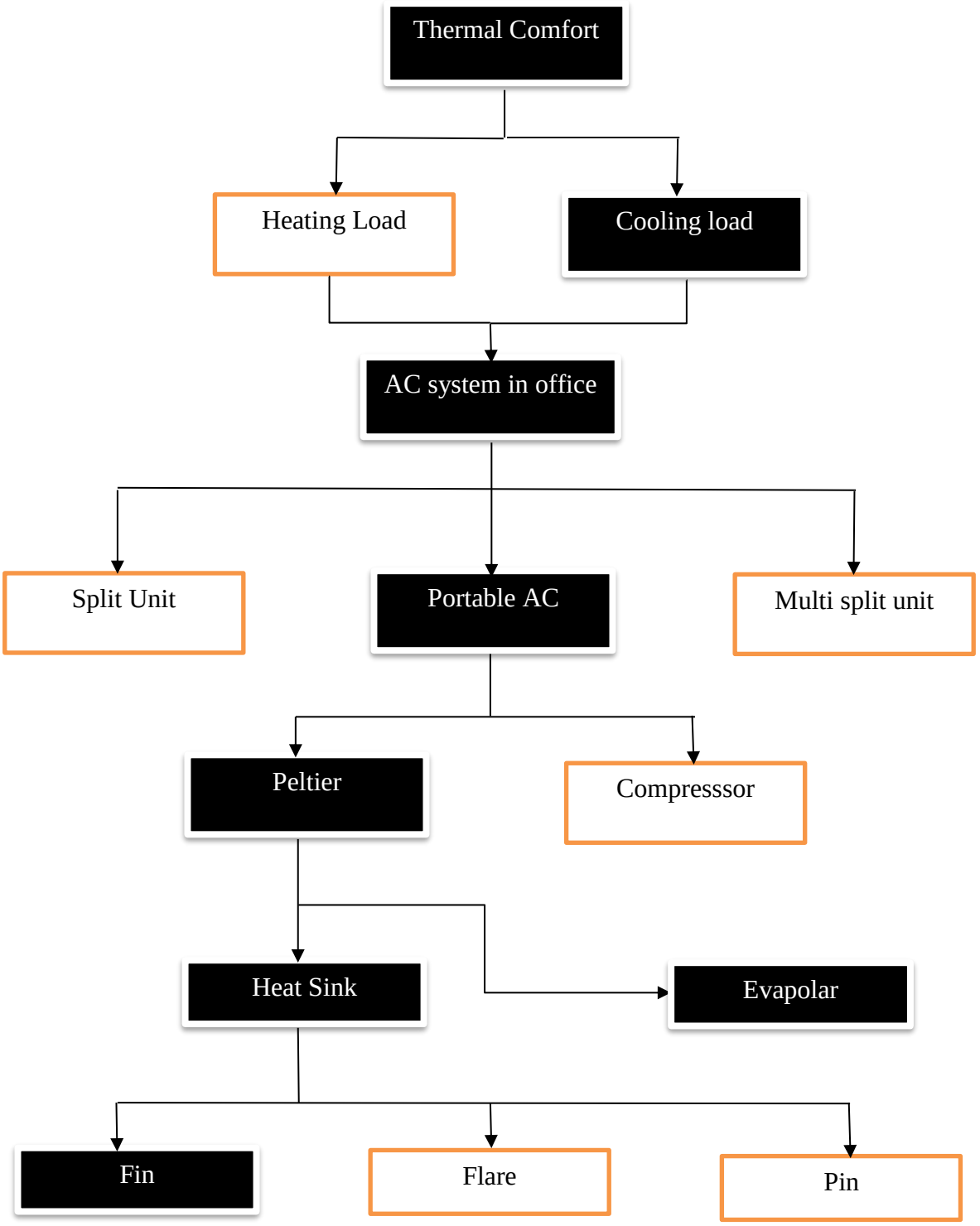

Figure 2.1: K Chart

2.2 Thermal Comfort

Human thermal comfort comes from the human body such as heat conduction, heat convection, clothes and metabolism rate of a human. The state of the thermal comfort of a person has a close relationship with the physical and mental of themselves (Luo *et al.*, 2018). The thermal comfort is different for everyone and it depends on the pleasure for each person. Based on the psychometric chart shown in Figure 2.2, a thermal comfort zone for a person is in the green range.

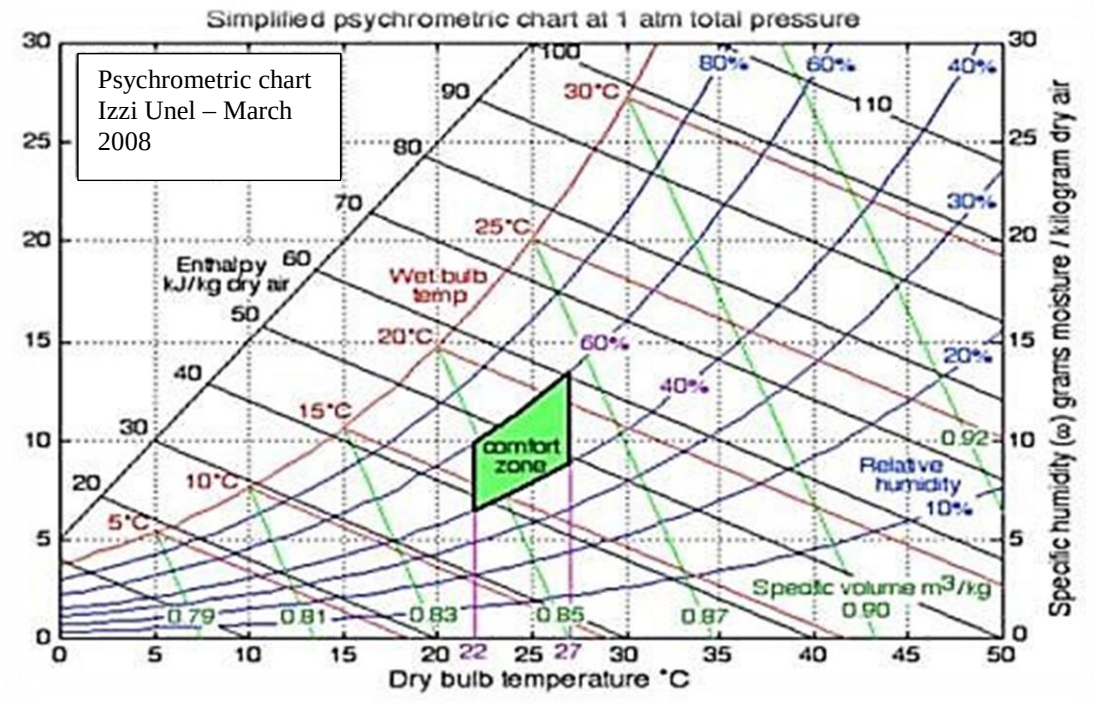

Figure 2.2: Psychometric chart of the comfort zone (ASHRAE (American Society of Heating Refrigerating and Air-Conditioning Engineers), 2009)

According to from a study from Dr. Choong Weng Wai and Mohd Suharizal Muhamad Subri, a thermal comfort zone for office buildings in Malaysia is between 24 ^{o}C to 25 ^{o}C with relative humidity between 50% to 65%. The relevant of this research makes

the Government of Malaysia ordered all office buildings in Malaysia not to set the temperature of the air conditioning system below then 24 ^{o}C. (The Star, 2011).

2.3 Cooling Load

Cooling load is an energy that must be evacuated from space to keep humidity and temperature at specific conditions. Figure 2.3 shows there are several types of sources in generating heat that is from heat conduction, heat convection inside a room, filtration of air, ventilation and sun radiation. Besides that, categories the load components can be divided into three category, which is internal load, external load, and others load. External load is the heat from outside penetrate inside a room via infiltration of outdoor air or solar heat gains from the source. Internal load is load created from inside of the room within itself via electric equipment, appliance, and occupants. Other load means that loads come from energy losses such as friction loss in ducting. For a person to feel comfortable, cool air needs to be supplied to occupants sufficiently so that it will limit and save energy consumptions. In fact, the main cause of high energy consumption in Mexico due to the usage of the air conditioning system according to the Mexican Ministry of Energy (SENER). (Mexico, 2016)

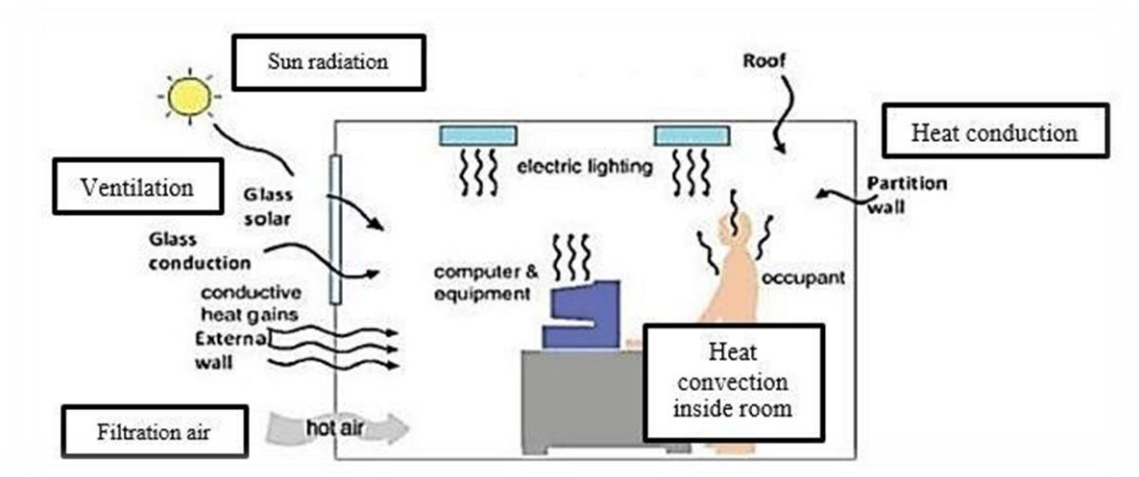

Figure 2.3: Various type of cooling load sources in an office

2.3.1 Office Cooling Load

Private office cooling load in contrast to the larger building due to its greater area in terms of range and volume occupied. Based on the rule of thumb table, private office inhabitancies are 150 ft^2/person, lighting watt is 4 Watts/ft^2 and room sensible is 25 btuh/ft^2. This information shows that the size of the office can be determined by the cooling load of the office room. Office cooling load is less, so it requires a small system to removes heat in the office, which is 3000 BTU/hr to 5000 BTU/hr (SAHU, 2014).

2.4 Air Conditioning system in an office

Nowadays, Malaysia has been facing a hot climate hotter than usual. Expertise in Meteorology department has discuss this situation with the help of members and model analysis such as NCEP coupled forecast system model version 2 (CFSv2), JMA Ensemble Prediction System (Tokyo Climate Centre), European Centre for Medium-Range Weather Forecast (ECMWF) and Seasonal Climate Forecast, International Research Institute for Climate Society (IRI) have reported that this hot weather starts from March 2019 until August 2019. This global phenomenon influenced current weather conditions to cause by El-Niňo Southern Oscillation (ENSO), Madden-Julian Oscillation (MJO) and Indian Ocean Dipole (IOD) as one of the factors that had been counted. (Malaysian Meteorological Department, 2019). Due to this acknowledgment, almost all buildings in Malaysia are using the air conditioning system. Not only in large buildings, but the small office also needs cool air to ensure a comfort zone. Each air conditioning system has a variety of cooling and heating capacity required. Besides that, all of these systems are using the same mechanism. Besides that, the several main types of air conditioning systems such as:

- Single Split System
- Multi-Split System
- Portable Air Conditioning

2.4.1 Split System Air Conditioning

Single splits are the most affordable Air Conditioning System in terms of price and efficiency for the use of small buildings or office rooms. It connected with one outdoor unit to one indoor unit as shown in Figure 2.4. For office rooms, it aims to provide cooling that makes users feel more comfortable in terms of thermal comfort. The advantages of this unit are the cheapest among all types of units and provide adequate energy consumes. Split units are the most popular in delivering cool air in small rooms due to suitable for their applications.

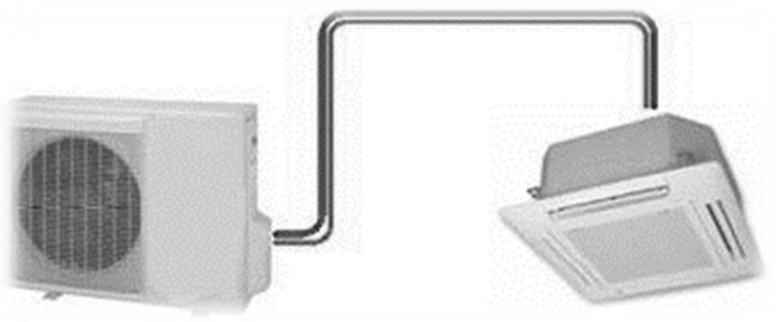

Figure 2.4: Split unit