UNIVERSITI TEKNIKAL MALAYSIA MELAKA

HEAT RECOVERY PROCESS IN DESIGN AND DEVELOPMENT OF INTEGRATING HOT WATER DISPENSER WITH PORTABLE AIR CONDITIONER BY USING PELTIER EFFECTS

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

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I hereby declared this report entitled "Heat Recovery Process in Design and Development of Integrating Hot Water Dispenser with Portable Air Conditioner by using Peltier effects" is the results of my own research except as cited in references.

Signature	: ………………..
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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:

………………………………

(Mohd. Farid Bin Ismail)

Project Supervisor

ABSTRAK

Penyelidikan ini adalah untuk merekabentuk dan mencipta dispenser air panas dengan menggunakan kaedah proses pemulihan haba dengan penyaman udara mudah alih yang terhasil dari kesan Peltier. Produk ini menggunakan kaedah pemindahan haba untuk menghasilkan dispenser air panas dan sistem sedia ada juga telah diubahsuai dan mampu menghasilkan angin yang sejuk dari kesan sejuk Peltier pada tahap minimum iaitu 5°C dalam pada masa yang sama mampu memanaskan air di dalam tangki simpanan sehingga 83°C bagi tahap maksimum. Proses pemanasan air dalam tangki simpanan juga turut dibantu dengan menggunakan penebat haba agar haba tidak terbebas keluar. Oleh itu, dengan menyatupadukan pelbagai kaedah dan konsep yang betul, kajian ini telah menghasilkan satu penyelesaian kearah teknologi hijau yang lebih selamat bagi pengguna. Seterusnya, kajian ini juga telah membezakan dua jenis bahan yang berlainan untuk tangki simpanan seperti tangki simpanan tin dan tangki simpanan aluminium mempunyai penebat atau tidak mempunyai bahan penebat. Hasilnya, kekonduksian haba yang lebih tinggi akan menghasilkan pemindahan haba yang lebih tinggi di kawasan unit terpilih. Konklusinya, sistem ini mempunyai kecekapan terma sebanyak 99.80 peratus. Ini bermaksud 99.80 peratus tenaga yang dipulihkan menjadi sumber kepada sistem disepenser air panas.

ABSTRACT

This report is about Heat Recovery Process in Design and Development of Integrating Hot Water Dispenser with Portable Air Conditioner by using Peltier effects. The prototype used a heat transfer method to increase hot water temperature in the storage tank and a process of heat waste recovery undergoes to improve the thermal efficiencies equally for both sides of the Peltier effects. The current system capable to distribute cooling air from cold side Peltier at lowest 5°C and gain hot water out from the Aluminium storage tank at the highest temperature which is 83°C. The process of heating the water in storage tanks is also assisted by the use of heat Aluminium foil and black rubber foam insulation so that heat is not released to the surrounding. By combining multiple works with portable equipment concept, this research has found a solution for a better green energy safety in creating a prototype for the needs. For more, this research has differentiated between two types of the material tank; tin tank and Aluminium tank with and without insulation. The results prove that the higher thermal conductivity will produce higher heat transfer from one surface to another surface per unit area. Hence, the thermal efficiencies are 99.80%. This means that 99.80% of energy has been recovered to the hot water dispenser. Somehow, the heat loss still happen in a small amount which is below than 0.20% or lesser.

DEDICATION

This project and research work are dedicated to my beloved husbands, Ahmad Nawawi bin Mohd Amin and my precious parents Ahmad Saifulzaman bin Abdul Rahim and Nor Hayati Binti Mohd Nor for their enthusiastic caring throughout my life, my loving siblings, my supervisor, Mohd Farid bin Ismail and also my friends for their encouragement and love.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

Std.	-	Standard Deviations
HFC	-	Hydro fluorocarbons
CFCs	-	Chlorofluorocarbons
CO2	-	Carbon dioxide
AC	-	Air conditioning
ASHRAE	-	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
Al	-	Aluminium
ASEAN	-	Association of Southeast Asian Nations
Cl	-	Chlorine
RM	-	Malaysian Ringgit
HVAC	-	Heating, Ventilating and Air Conditioning
k	-	Thermal conductivity constant value
x	-	Thickness
S	-	Cross-sectional area (m^2) of waste flow pipe/ducting
V	-	Flow velocity (m/sec)

CHAPTER 1

INTRODUCTION

1.0 Background

The cooling area for a person to feel comfortable is the cool air need to be distributed only at 1-1.5 meter around a person. The using of the split unit air conditioning system in a private room or cubical place for an employee can waste the energy consumptions and cost for a higher bill to pay. A previous research (Aziz, 2017) has developed a portable air conditioner by using Peltier effects to overcome the waste of energy consumptions. The effects of cool side Peltier fully utilized but vice versa to the hot effects of the Peltier. In the same contents, the portable air conditioning product has reached a great achievement in order to use the cool effect by distributing the cool air from Peltier effects but then some problem needs to be fixed where the hot side of Peltier is not used. The heat waste loss to surrounding in a large amount. This problem would affect the Peltier performance. As a solution, by combining multiple works with portable equipment concept, the waste heat undergoes heat recovery process to be a hot water dispenser. To achieve the Thermodynamics First Law where energy cannot be destroyed and will be converted to another form, this research will design a new product integrating of the portable air conditioner with hot water dispenser in using both side effects of Peltier plate by applying the heat recovery process.

1.1 Problem Statement

From the previous product of portable air conditioning, the heat wasted to surrounding because of the unorganized energy used. This research will redesign the portable air conditioning integrated with hot water dispenser in order to use the heat energy that been liberated. The prototype needs to be upgraded for a better purpose so the device is ergonomics to all users. The heat loss will be recovered to heat up the water in the storage tank. For more, since the Peltier effects are too sensitive, both heat effects need to be conducted and used in a proper way.

1.2 Aim and Objectives

This project aim is to redesign and upgrades existing product of Portable Air Conditioning integrating with The Hot Water Dispenser by using Heat Recovery Process by applying the Peltier module. The heat recovery process is expected to heat up the water return into the storage tank in enclosed spaces. There are several objectives to achieve the aims:

1. To develop a hot water dispenser integrated with portable Air-Conditioning (prototype) by using the heat recovery process.
2. To upgrade the design of portable Air Conditioner from the previous project by using both Peltier effects.
3. Determine the thermal conductivity between three properties and material type of the storage tank that related to the heat transfer process. The tanks mentioned are;

    i. Tin tank without insulation
    ii. Aluminium tank without insulation
    iii. Aluminium tank with insulation

4. To calculate the percentage of thermal efficiency of the selected tanks that undergoes heat recovery process.

1.3 Scope

The scopes of study and limitations of this project are:

1. Focusing on the ability to recover the excess heat thermal generate and liberated from the Peltier.
2. Focusing on the high thermal conductivity of the storage water tank's material will increase the heat transfer rate to rise into the highest temperature (hot water) can be achieved inside the storage tank.
3. The hygiene of water (tap water) is safe to drink but still need to add any source of energy to boil the water until 100 ºC.
4. The prototype only can achieve a maximum temperature at only between 73°C - 83°C at given power supply and as based on its limitation performance of the Peltier.
5. Peltier module takes time to gives the desired temperature.
6. The hot water dispenser is restricted / effective to a small volume of water at a time to undergo the fastest heat transfer process.
7. The product continuously rises in temperature and has no automatic thermostat sensor that gives the signal to Arduino to stay fix at the desired temperature.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter is to elaborate more about the development process of prototype in applying various method based on the preview journal. This chapter also to analyse as much as can, the possible way to have the best idea in development and integrating Portable Air Conditioning with The Hot Water Dispenser by using Heat Recovery Process.

2.1 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 2.1 shows there is five sources of heat generate where from sun situated radiation, heat conduction, heat convection, ventilation, and filtration air as the figure below.

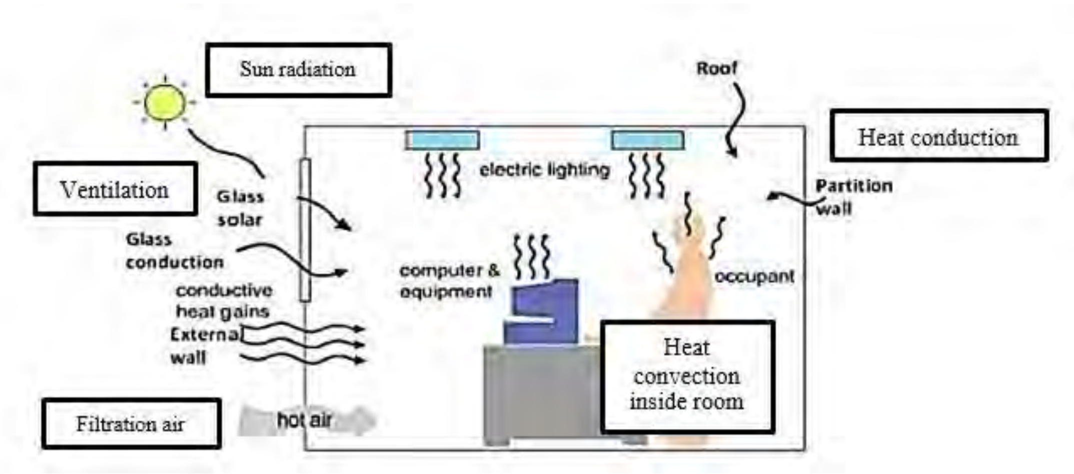

Figure 2.1: Various type of cooling load sources in an office

The figure 2.1 shows the cooling load component included 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).

2.1.1 Office cooling load

Private office cooling load is different compared to manufacturing plant based on greater space sense of the range and volume of space is influenced the cooling load. Based on the rule of thumb table, private office inhabitancies are 150 ft2/person, lighting watt is 4 watts/ft2 and room sensible is 25 btuh/ft2. By this information, a cooling stack of office room can be decided depending on the estimate of office. Office cooling stack is little at that point require a little framework to expel the sensible and inactive warm interior the office which is 3000 btu/hr to 5000 btu/hr (SAHU, 2014).

The general guideline is the most straightforward approach to discover cooling load however not exact as another technique. The factor maybe differs from each district and places, hence this rules of thumb may be used only as for guidelines for obtaining the real value.

2.2 Thermal comfort

Human thermal comfort thermal comfort is effected may come from the body heat conduction, convection, and sort of dress and rate digestion system of a human. The state of thermal comfort of a person has a close relationship with the physical and mental of themselves (Luo *et al.*, 2018). Each person has particular fulfilment on the condition of heat thermal. Based on figure 2.2 the psychometric chart, thermal comfort can be achieved when a person is in a comfort zone (green space).

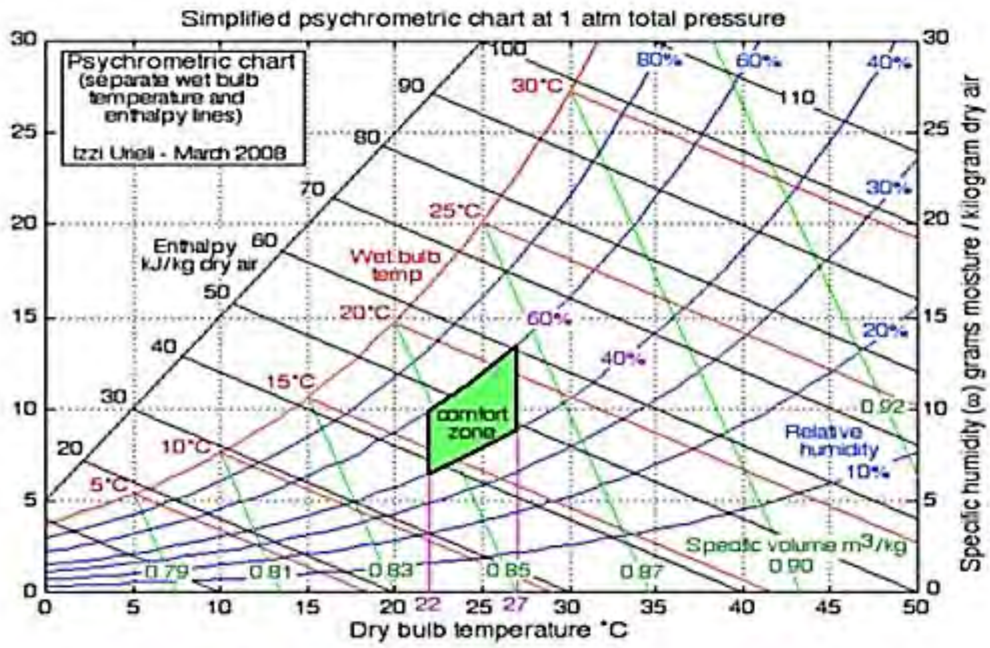

Figure 2.2: Psychometric chart of the comfort zone (ASHRAE (American Society of Heating Refrigerating and Air-Conditioning Engineers), 2009)

Table 2.1 shows the acceptable range of each parameter for thermal comfort in average for up to 8 hours per day. These factors are included the necessity of real condition users guideline to achieve the best thermal comfort for people in a building.

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

Parameter	Acceptable range (TWA)
Temperature (°C)	22 – 27 (Based on figure 2.2)
Relative humidity (%)	40-70
Air velocity (m/s)	0.15-0.50

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

2.3 Refrigerants Uses

The blending of chemicals contained in the refrigerant is a huge impact on ozone exhaustion and climate alter in the world. The use of CFCs and HCFCs and chlorine substance is the primary cause of the exhaustion of the ozone layer (Riffat S, Afonso C, Oliveira A et al, 2011). This portable product is one invention from best effort to save the world using the hundred percent of water and no refrigerants involve as cooling substance.

2.3.1 The basic cycle of refrigeration

The fundamental of the refrigeration cycle is compressor will compress the gas stage of refrigerant. At this compression, the gas refrigerant will increment the temperature and weight of the next component which is a condenser. The condenser is a heat remover; the compressed gas will go through the condenser and drop the temperature but the weight remains same. The gas refrigerant will turn into fluid refrigerant after through the condenser as the condensation handle happened.

Liquid stage of refrigerant will through a development valve, the temperature and weight will drop at this point and straight to the evaporator. The evaporator is a heat safeguard; the liquid stage of refrigerant through an evaporator, vanishing handle happened will alter the fluid to the gas stage and the temperature will marginally increase (Wang, 2000). Figure 2.3 shows the basic diagram of HVAC where the red line represents the high-pressure line and the blue line is the low-pressure line.

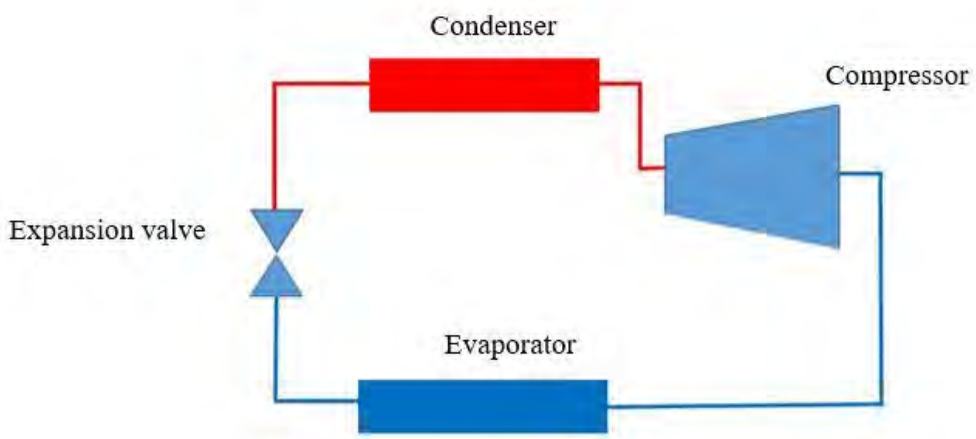

Figure 2.3: The basic cycle of the refrigeration cycle

The product development of hot water dispenser integrating with portable air conditioner will use the same system as refrigerant cycle system but differs in mechanical component uses such as the heat sink will act as the evaporator and the motor will act as the compressor. However, the heat waste from Peltier effect that acts as condenser will be recovered to heat up the water in dispenser tank.

2.4 Comparison of the split unit and portable Air conditioning unit

Figure 2.4 is split unit Air conditioning type and figure 2.5 is the portable unit Air conditioning type. Both Air conditioning unit is differentiated to compare for a better efficiency system use and the best solution to use the lower consumptions of power and lower in bill costing. Moreover, the maintenance system has also been mentioned and the lousy noise produces by each of the units also been differentiate.

Figure 2.4: Daikin split unit (Daikin, 2018)

Figure 2.5 Daikin portable unit (Daikin, 2018)

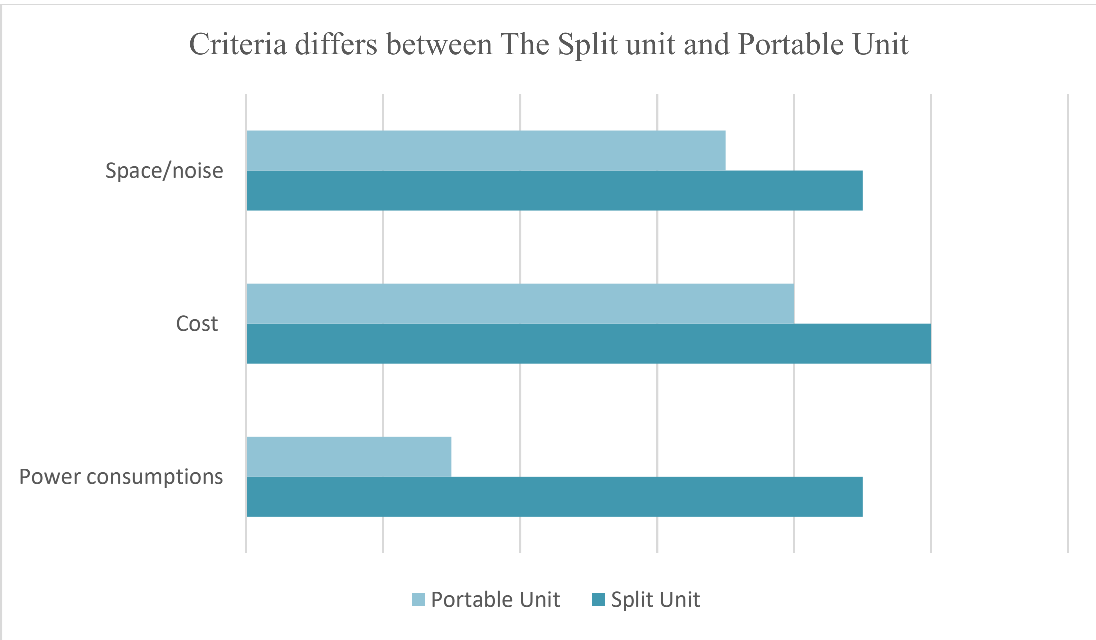

Figure 2.6: Criteria differs between The Split unit and Portable Unit

Figure 2.6 shows the Criteria differs between the Split unit and Portable Unit above the space and noise of Split unit is leading the portable unit. This is because the