UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: PROTOTYPE OF WATER-COOLED CONDENSER FOR SPLIT UNIT AIR-CONDITIONER

SESI PENGAJIAN: 2017/18 Semester 1

Saya MOHD AMER FAZRIEL BIN MOHD ZAIN

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:

_____ _____

Alamat Tetap:

LOT 1042 LORONG KELAPA WANGI
16150 KOTA BHARU, KELANTAN

Cop Rasmi:

Tarikh: _____

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.

DECLARATION

I hereby, declared this report entitled "Prototype of Water-Cooled Condenser Cooling System for Split Unit Air-Conditioner" is the results of my own research except as cited in references.

Signature : …….

Author's Name : MOHD AMER FAZRIEL BIN MOHD ZAIN

Date : ……

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:

……

Norain Binti Idris

(Project Supervisor)

ABSTRACT

Air-conditioning plays an important role to produce comfort conditions in which the human being tend to feel highly comfortable. The most popular type that is used in residential is split-unit type air-conditioner. The efficiency of the split unit air-conditioner can be calculated using coefficient of performance (COP). This project focus on water-cooled condenser cooling system at residential air-conditioner because of COP of the system with usage of water-cooled condenser is higher compare to air cooled-condenser. Usually water-cooled condenser can be found at chiller system, been used only for large industrial area and rarely found in residential air-conditioner. Therefore, this project aims to developed water-cooled condenser for residential air-conditioner system. Prototype of 1.0hp Mitsubishi split unit air-conditioner with water-cooled condenser cooling system will be used to measure and calculate the COP. As comparison to system with usage of air-cooled condenser, the COP of system with usage of water-cooled condenser is measured and calculated. As the result, the COP system with water-cooled condenser is equal 4.4 as compared to COP of system with air-cooled condenser is equal to 3.7. COP of the system increased 19 when using water-cooled condenser.

ABSTRAK

Penghawa dingin memainkan peranan penting untuk menghasilkan keadaan selesa di mana manusia cenderung merasa sangat selesa. Jenis yang paling popular yang digunakan di kediaman ialah penghawa dingin jenis unit split. Kecekapan penghawa dingin unit berpecah boleh dikira dengan menggunakan pekali prestasi (COP). Projek ini memberi tumpuan kepada sistem penyejukan kondenser yang disejukkan dengan air. Biasanya kondenser yang disejukkan dengan air boleh didapati di sistem penyejuk, digunakan hanya untuk kawasan perindustrian yang besar dan jarang ditemui di penghawa dingin kediaman. Oleh itu, projek ini bertujuan untuk membangunkan kondenser yang disejukkan dengan air untuk sistem penyaman udara kediaman. Prototaip 1hp Mitsubishi split unit penyejuk udara dengan sistem pendinginan kondenser yang disejukkan dengan air akan digunakan untuk mengumpul COP. Sebagai perbandingan kepada sistem dengan penggunaan kondenser yang disejukkan dengan udara, COP sistem dengan penggunaan kondenser yang disejukkan dengan air diukur dan dikira. Sebagai hasilnya, peningkatan COP adalah sekitar 19%. Sistem COP dengan kondenser yang disejukkan dengan air = 4.4 berbanding dengan COP sistem dengan kondenser yang disejukkan dengan udara = 3.7

DEDICATION

To my beloved parents, I acknowledge my sincere indebtedness and gratitude to them for their love, dream and sacrifice throughout my life. I am thankful for their sacrifice, patience, and understanding that were inevitable to make this work possible. Their sacrifice had inspired me for the day I learned how to read and write until what I have become now. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my dream. Lastly, I would like to send my gratitude to any person that contributes to my final year project whether it is directly or indirectly. I would like to acknowledge their comments and suggestion, which are crucial for the successful completion of this study.

ACKNOWLEDGEMENT

First and foremost, all praise to Allah the almighty for giving me the strength, health, knowledge and patience to successfully complete this Final Years Project in the given time. I must thank my parents for their love and support through my life. thank you for giving me strength to climb the stairs and walking towards the paths of life. I would like to address my deepest appreciation to the supervisor, madam Ain binti Idris for his encouragement, comments, guidance and enthusiasm through the time developing the report. Special thanks to my friends that have been through thick and thin throughout the completion of this project. This project report might be impossible to complete without all your help. Finally, thank you to everyone that directly and indirectly involved in helping me finishing this finale Year Project report. Thank you.

TABLE OF CONTENT

CHAPTER 4

CHAPTER 5

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.0 Introduction

Air conditioning is a device that produce an air treatment to control temperature, moisture content, quality and circulation in a space or building. Air-conditioning system usage has been famous nowadays through the world used by the people or community. Air-conditioning plays an important role to produce comfort conditions in which the human being tend to feel highly comfortable. The air-conditioning system such as centralized and decentralized are the examples of air-conditioning system that are commonly used in residential. Centralized air-conditioning system serve multiple spaces in one location, use chilled water as cooling medium and use extension ducting. Decentralized air-conditioner system served small spaces or room within direct adjacent to space (Bhatia, 2011). Types of decentralized air-conditioner system that are commonly used in residential are window air conditioner, split air conditioner system, variable refrigerant flow (VRF) split system and packaged air conditioner. The most popular type that is used in residential is split-unit type air-conditioner. Split-unit type air conditioner can be divided into two types that are split unit and multi-split unit air conditioner. Split-unit type air conditioner also comes with non-inverter and inverter models. Inverter split-unit type air conditioner system comes with varies speed of compressor and usage of R410A refrigerant. For non-inverter or fixed speed air conditioner system, it comes with fixed compressor and usage of R-22 refrigerant. Split unit air conditioner consists of one indoor and one outdoor meanwhile multi-split unit consist of multiple indoor unit connected to the one outdoor unit using difference pipe lines. The split-unit type air-

conditioning is produced to cool the air to indoor or inside the building and release the heat to the outside of building using condensing unit. The indoor unit consists of evaporator and outdoor unit consists of compressor, condenser and expansion valve. The split unit air conditioner condenser uses fan to cool the condenser and produces temperature about 312 K in contours of the inner condenser exhaust (Bojic, Lee, & Yik, 2001). The performance of condenser unit is based on the temperature drop of refrigerant pass through condenser using the variable type of condenser. The performance of split unit type air conditioning system can be determine using the coefficient of performance (COP).

1.1 Problem statement

Nowadays, residential air-conditioning condenser system (split unit) uses air as a medium to cool the refrigerant. Long term use of air-condenser will produce fouling at condenser fins and can potentially increase energy consumption or/and decrease efficiency of cooling capacity (Qureshi & Zubair, 2014). High condensing temperature at air-cooled condenser also augment the pressure ratio which reduces compressor life and COP. Compare to the usage of air-cooled condenser, water-cooled condenser have lower condensing pressure, condensing temperature and reduce the compression work (Raveendran & Sekhar, 2017). Normally, water-cooled condenser been used in commercial HVAC system but in this project water-cooled condenser been apply at residential air-conditioning system. Prototype of water-cooled condenser for residential (split unit air-conditioner) had been produce at China and the result show coefficient of performance (COP) water-cooled condenser is 17.4% higher than air-cooled condenser(Chen, Lee, & Yik, 2008). Water-cooled condenser for residential air-conditioner had been produced in China used cooling tower to reject heat from water. Cooling tower is not suitable for residential building because it required large space area for installation and have high construction cost. Existing residential air-conditioner that used water-cooled condenser also produced waste water at evaporator and it flow out to

the outside of building without being used. Therefore, this project use waste water from evaporator as a backup for receiver tank.

1.2 Objectives

This project aims to fulfil the following objectives:

i. To design and fabricate a prototype of water-cooled condenser cooling system for residential split unit air-conditioner.

ii. To investigate the effect of water-cooled condenser cooling system to the coefficient of performance (COP) at split unit air-conditioner.

1.3 Scope

The scope of work for this study involves testing of water-cooled condenser system at 1.0hp Mitsubishi split unit type air conditioner. The refrigerant used in this air conditioner is R-22. Water cooled-condenser system been design and integration with existing air-cooled split unit system (by using host pipes and receiver tank). These components are used for production of circulating water flow in water-cooled condenser and to remove heat from water. wasted water from evaporator been used as a backup water to avoid the water drain from receiver tank.

CHAPTER 2

LITERATURE RIVIEW

2.0 Introduction

This chapter proceeds with a fully referenced review from the relevant literature. The Figure below show all topic that will be explain in detail to produce water-cooled condenser cooling system on split-unit air conditioner with water from evaporator as a backup.

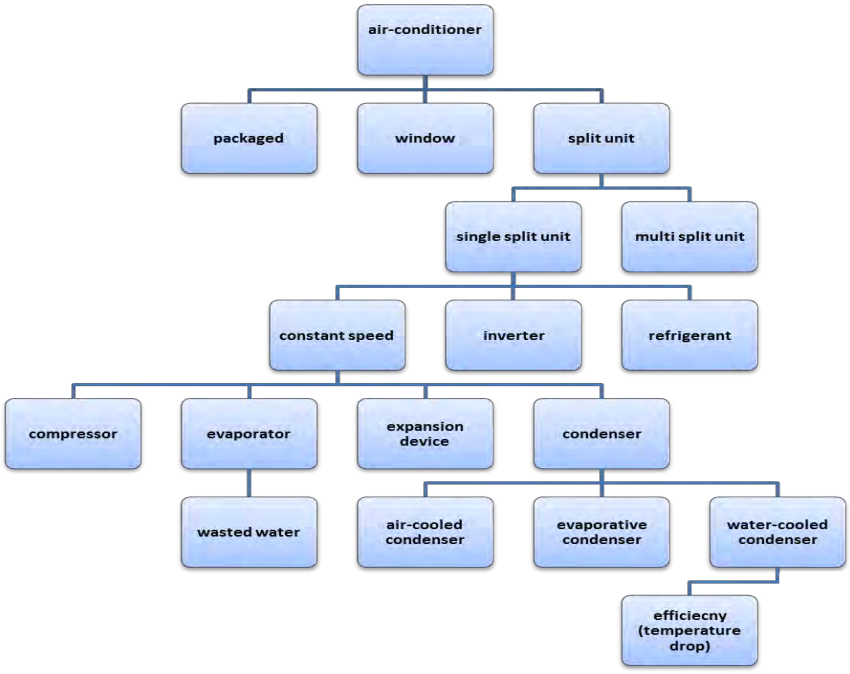

Figure 2. 1: Summary of topics that will be cover

2.1 Type of Air Conditioning System

There are several types of air-conditioning system available today and each type have their own advantages and been used for varying applications. Selection of type of air-conditioning system based on specific criteria such as total space area to be cool, overall cost, application of the building and energy efficiency.

Types of air-conditioning system:

a) Window air-conditioner

Window air-conditioner usually been used for a small space area. In this air-conditioner all components, namely the evaporator, compressor, condenser and thermal expansion valve been installed in a single box house. All the components are assembled inside the casing and been install on the wall which casing of the air-conditioner is been fitted into the wall or window of the room. Window air-conditioner can be divided into two compartments which are the room side and the outdoor side. On the room side, the casing is decorated beautifully and consists of supply and return air grills and commonly called as front grill. Outdoor side consists of condenser system in which heat is removed to the atmosphere. Figure 2.2 show type of window air-conditioner.

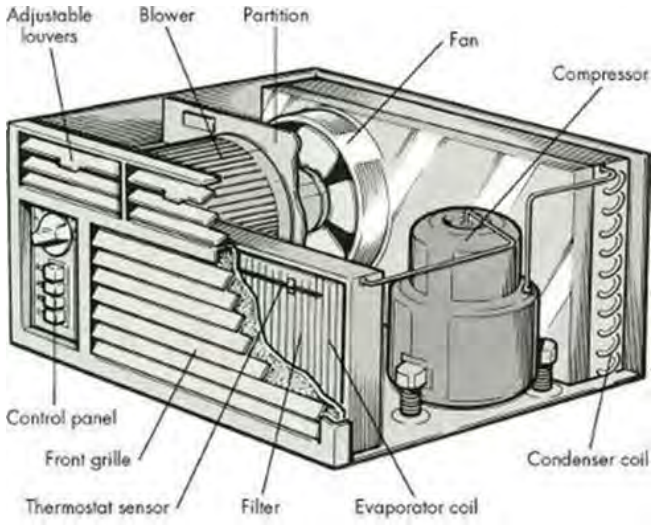

Figure 2. 2: Window air-conditioner

b) Package terminal air-conditioner

Window air-conditioner and split unit-air conditioner normally use for residential or small air-conditioner capacities. Using the same concept as split unit and window unit air-conditioner, packaged terminal unit air-conditioner is used for largest cooling load capacity extend beyond 20 tons and often found in hotels or offices. All the component consists of compressor, condenser, expansion valve and cooling coil installed together in cabinet casing with an addition of its own air handler unit and filter. Normally packaged terminal air-conditioner placed on the roof or a concrete slab near the foundation. Packaged terminal air-conditioner supply the air to the rooms using ducting system. Packaged terminal air-conditioner condenser can be cool either using water or air. Generally, water is chosen to cool the condenser using cooling tower because the usage of water is more efficient compared to air-cooled condenser. Figure 2.3 show terminal package air-conditioner.

Figure 2. 3: Package terminal air-conditioner

c) Split unit air-conditioner

This type of air-conditioner been used in this project. Usage of split-type air-conditioner in office buildings and residential been famous due to the simplicity and flexibility (Avara & Daneshgar, 2008). Normally, small and medium residential building used split unit air-conditioner (Elsayed & Hariri, 2011). Split type air-conditioner comprises of two parts which is indoor unit and outdoor unit. Indoor unit been installed on the wall inside the room and consists of evaporator or cooling coil and cooling fan. The most common type of the indoor unit is the wall mounted type. However, other types such as ceiling mounted and floor mounted are also used. Outdoor unit are normally installed on the outside of the rooms and contain condenser, compressor and thermal expansion valve. Indoor and outdoor unit are connected together using copper pipes. Split unit air-conditioner can be used to cool down more than one room. Variable indoor unit with single outdoor unit can be used on multiple rooms and been call multi-split unit air-conditioner. Figure 2.4 show split unit type air-conditioner

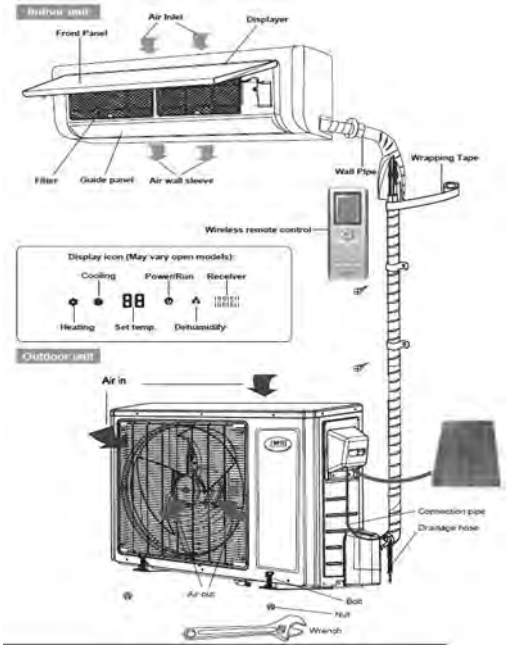

Figure 2. 4: split unit air-conditioner

2.1.1 Types of Split Unit Air Conditioner

i. Multi split unit air-conditioner

Multi-split unit air-conditioner consists of one indoor unit with multiple outdoor units. The purpose of multi-split unit air-conditioner is to cool multiple zone interior space. All the indoor units are connected to the outdoor unit using different piping lines. Total of piping lines depends on the number of indoor units that are used in the building. The usage of multi-split unit air-conditioner solves the outdoor unit arrangement problem because it only used single outdoor unit. Total cooling load of indoor units and outdoor unit need to be balance in order to produce high performance result. Furthermore, this type of air-conditioner can be used to cool certain rooms at certain times which means not all the indoor unit need to be switch on to make the system run.

ii. Single split unit air-conditioner

This type of split unit air-conditioner been used in this project. Split unit air-conditioner involves of an indoor and an outdoor unit and it is used to cool single zone interior space. One single line piping system is used to connect the outdoor unit with indoor unit to complete the refrigerant flow through all four main components. Usually, the limit connection between the indoor and the outdoor unit is around 100 feet. Flexibility is the overriding advantage of the split unit system because the indoor unit and the outdoor unit are connected through a custom refrigerant piping system (Bhatia, 2011) . For example, outdoor unit can be install either at on the side, rear or roof of the building. Usage of split unit air-conditioner been famous in residential area and small building because it can be installed simply and did not need attachment of ducting system. Usage of split unit air-conditioner normally need a large space area for the installation of outdoor units.

2.2 Model of split unit air-conditioner

Split unit air-conditioner have improved rapidly to increase the efficiency of the system. A lot of improvement had been done to create system that is more efficient compared to the previous system. The improvement of split unit air-conditioner has produced two models that is constant speed and inverter.

2.2.1 Inverter

Inverter air-conditioner is the latest evolution of technology consist of electro motor of the compressor. Improvements and reduction in the energy consumption of refrigerator compressors is crucial for the refrigeration industry (Ekren, Celik, Noble, & Krauss, 2013). The function of inverter is to control the speed of the compressor. Inverter compressor run at variable speed, at a low speed when the room in the right temperature and speeds up when the temperature increased. Compared to the constant speed air-conditioner, inverter compressor produced silent sound when in use because the compressor speed is controlled according to the room temperature which minimize the vibration on the compressor. Inverter air-conditioner also cool the room at a constant temperature that lead to the comfortable rooms. In term of power consumption, inverter saved more energy compared to the constant speed because of the control over compressor speed reduced the usage of electrical power. The refrigerant used in inverter is R-410a.

2.2.2 Constant speed

Constant speed is a traditional room air-conditioner and can be found at windows or split unit air-conditioner. Constant speed air conditioning units are units that have constant speed compressor. This unit only has a single speed compressor motor that is either on or off which mean compressor only operate at maximum capacity or switched off. Constant speed compressor cold the room for short time because the compressor will

turn on after the temperature in the room increased. Furthermore, the usage of constant speed air-conditioner produce unpleasant sound that is caused by vibration. When the temperature start going up, the compressor will start to run at maximum capacity hence the unpleasant sound produced. Constant speed compressor is less efficient in term of power consumption because the compressor will always run at maximum capacity when it is started which will result in the large usage of electrical power. Normally, the refrigerant that is used in constant speed is R-22. This model is used in this project.

2.2.3 Refrigerant used

Refrigerant is a fluid that is used in the air-conditioning system. It is a chemical used in a cooling mechanism, such as an air conditioner. The function of refrigerant is as a heat carrier which changes from gas to liquid and then back to gas in the refrigeration cycle. Refrigerant acts as a transportation medium to move heat absorbed in the evaporator to the condenser where it is rejected. Refrigerant flows in the copper pipe through two unit that is indoor and outdoor unit. In the indoor unit, refrigerant flow in evaporator cooling coils to absorb heat from surrounding area and delivered cool air. Then, refrigerant flow in the outdoor unit to remove the heat using condenser coils. Normally, two type of refrigerant used in residential area that is R-22 which is hydro-chlorofluorocarbon (HCFC), and R-410a which is hydrofluorocarbon (HFC). For this project, refrigerant type R-22 been used to conduct the experiment. Hydro-chlorofluorocarbon R-22 often called by it brand name, Freon has been used in air-conditioning system for decades (Elgendy, Hassanain, & Fatouh, 2015). The problem with this refrigerant is it is less efficient and produced bad result on the environment. (Ekren et al., 2013)m show that R-410a produced higher condensation heat transfer coefficient compared to the R-22. R-22 also produced bad result to the environment because it has been contributed to the depletion of ozone layer. The table show difference between R-22 and R-410a in term ozone depletion potential (ODP).

Table 2. 1: Ozone depletion potential

Refrigerant	Ozone deplation potential (ODP)
R-22	0.055
R-410a	0

Due to the ozone depletion potential, one environment protection agreement has been created to phase out refrigerant R-22. In September 16,1987 Montreal Protocol been signed by all 197 member countries of the United Nation to eliminate (HCFC) R-22 (United Nations Industrial Development Organization, 2011). In 2010 R-22 is no longer allowed to be used in the new air-conditioner and according to the Montreal Protocol phaseout schedule, there is no more production of any HCFC in 2030 in developed countries and 2040 in developing countries (Shaik & Babu, 2017). Hydrofluorocarbon (HFC) R-410a has been commercialised in the 1990s to replace R-22 in the air-conditioning system (Longo, 2010). R-410a is a combination of two hydrofluorocarbons that is difluoromethane and penthafluoroethane. This refrigerant been used to replace R-22 because it is non-ozone depleting refrigerant and provide better energy efficiency. From the experimental result, 20% of the total power consumption comes from the usage of air-conditioner (Ekren et al., 2013). Therefore, R-410a has been used in air-conditioner to produce air-conditioning system with high energy efficiency. Compare to the R-22, R-410a is more efficient in absorbing and releasing heat. Unfortunately, all the common HFC refrigerant have a high global warming potential (GWP) that is higher than 1000 and had been defined as greenhouse gases under the Kyoto Protocol in 1997 (Nations, 1998). Therefore, some countries take an action towards a limitation in the use of HFC refrigerant.

2.3 Component arrangement

There are four basic components required to complete the refrigerant basic cycle. All the refrigerants use this system in a closed circuit. The same refrigerant is used in this cycle to cool the space area and to remove the heat to atmosphere. The four main components are evaporator, compressor, expansion valve and condenser.

2.3.1 Evaporator

Evaporator is a device that assembled in the indoor unit air-conditioners used to absorb heat and cool the space area. Refrigerant flow into the evaporator in low pressure liquid and flow out into discharge line in low pressure vapor after absorbed the heat from the space that is being cooled. Air from surrounding has been forced to the evaporator coil and fin using blower. The cooling process begin when the air flow passed through the evaporator coil for heat exchanger. The air produced at the evaporator flow to the space are cooled air.

2.3.1.1 Types of evaporator

There are several types of evaporators been used in air-conditioning system and been selected using their specific application and design. Normally evaporator selected depending on the construction of the evaporator. These are types of evaporator that commonly used in air-conditioning system:

a. Bare tube evaporator

b. Finned type evaporator

c. Plate type

d. Shell and tube evaporator