UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE ANALYSIS OF 1HP SPLIT TYPE ROOM AIR CONDITIONER USING REFRIGERANT R410A AND R32

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

TAN REN JIE
B071410263
940713-10-5129

FACULTY OF ENGINEERING TECHNOLOGY
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DECLARATION

I hereby, declared this report entitle

PERFORMANCE ANALYSIS OF 1HP SPLIT TYPE ROOM AIR CONDITIONER USING REFRIGERANT R410A AND R32

is the results of my own research except as cited in references.

SIGNATURE :

AUTHOR'S NAME : TAN REN JIE

DATE :

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements of the degree Bachelor of Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) with Honours. The member of the supervisory is as follow.

……..

(Mdm. Siti Nor'Ain Binti Mokhtar)

ABSTRAK

Penyaman udara adalah teknologi yang digunakan secara berleluasan bahawa udara dapat dikekalkan dalam suhu yang selesa atau suhu yang tertentu untuk keselesaan manusia. Permintaan global terhadap penyaman udara bilik jenis split meningkatkan setiap tahun dan menyebabkan iklim Bumi semakin teruk akibat pemanasan global disebabkan oleh pelepasan fluorin ke atmosfera daripada bahan penyejuk yang terkandung dalam peralatan penyaman udara. Untuk penyaman udara bilik jenis split, bahan peyejuk baru (R32) yang mempunyai potensi pemanasan global yang lebih rendah (GWP) telah dibangunkan sebagai pampasan dan untuk menggantikan bahan penyejuk yang digunakan kini (R410A) yang mempunyai GWP yang lebih tinggi dimana menyebabkan lebih banyak kerosakan kepada atmosfera. Objektif kajian ini adalah untuk mengumpul keadaan operasi (penggunaan tenaga, suhu, tekanan) dan "coefficient of performance" (COP) kedua-dua bahan penyejuk R410A dan R32 yang beroperasi di kedua-dua 1hp (kuasa kuda) peyaman udara bilik jenis split. Penyelidikan eksperimen melibatkan dua penyaman udara bilik jenis split 1hp yang menggunakan bahan penyejuk yang berbeza (R410A dan R32) dalam keadaan yang sama. Pengesahan akan dibuat berdasarkan data yang dikumpul semasa eksperimen. Instrumen seperti Termometer Digital, Manifold Gauges dan Power Quality and Energy Analyzer akan digunakan dalam membantu sesi mengumpul data. Analysis lanjut akan dijalankan terhadap data yang terkumpul semasa eksperimen secara manual dengan menggunakan (Mollier Chart) dan perisisan komputer (TechniSolve) untuk menentukan COP sistem tersebut. Kesimpulannya, penyelidikan ini adalah mengutamakan menyumbang kepada penentuan prestasi bahan penyejuk R32 dalam menggantikan bahan penyejukan kini R410A yang digunakan dalam penyaman dingin bilik jenis split.

ABSTRACT

Air conditioning is a widely used technology that conditions an indoor air to a comfortable temperature or a specific temperature adequate to human comfort. The global demand of split type room air conditioning system boosts every year and caused the Earth's climate worst as a result of global warming due to the emission of fluorine into the atmosphere from the refrigerant that contained in the air conditioning equipment. For split type room air conditioner, new refrigerant (R32) that have lower global warming potential (GWP) have been developed as compensate and to substitute the currently in used refrigerant (R410A) that has higher GWP which deals more damage to the atmosphere. The objectives of this research are to collate operating conditions (energy consumption, temperatures, pressures) and coefficient of performance (COP) of both refrigerant R410A and R32 that operated in both 1hp (horsepower) split type room air conditioners. The experiment research involved two 1hp split type room air conditioners which using different refrigerant (R410A and R32) under the same condition. Validation will be made based on the data collected during the experiment. Instruments such as Digital Thermometer, Manifold Gauges and Power Quality and Energy Analyzer will be used in aiding the data collecting session. The data collected will undergo further analysis by manually using Mollier Chart and software (TechniSolve) in determining the COP of the system. Conclusively, this research is mainly contributes for helping to determine the performance of refrigerant R32 in substituting the currently R410A using in split type room air conditioner.

DEDICATION

This dissertation is dedicated to my parents and siblings for their unfailing supports, unceasing encouragement, support and attention throughout my years of study and the process of this research and paper writing. This accomplishment would not have been possible without them.

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Foremost, I would like to express my sincere gratitude and appreciation to my supervisor Mdm. Siti Nor'Ain Binti Mokhtar for the continuous support, patience, motivation and enthusiasm throughout this research dissertation. The door to my supervisor was always open whenever I ran into a trouble or had a question about my research or writing.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AHU	-	Air Handling Unit
ASHRAE	-	American Society of Heating, Refrigerating and Air Conditioning Engineers
CCWS	-	Central Chilled Water System
CFCs	-	Chlorofluorocarbons
COP	-	Coefficient of Performance
DX	-	Direct Expansion
GWP	-	Global Warming Potential
HCFCs	-	Hydrochlorofluorocarbons
HFCs	-	Hydrofluorocarbons
HP	-	Horsepower
HVAC	-	Heating, Ventilating, and Air Conditioning
HVAC &R	-	Heating, Ventilating, Air Conditioning and Refrigerating
NASA	-	National Aeronautics and Space Administration
ODP	-	Ozone Depletion Potential
PAC	-	Portable Air Conditioner
WHO	-	World Health Organization
˚C	-	Degree Celsius
˚F	-	Degree Fahrenheit
h	-	Enthalpy

CHAPTER 1
INTRODUCTION

1.0 Background

Air conditioning is defined as a system for treating air in buildings, etc., so as to maintain those conditions of temperature, humidity, and purity best adapted to personal comfort, etc. (Funk & Wagnalls Inc., 1980). Air conditioning is use to alter and maintain an indoor air temperature at a specific temperature regardless the time or season of a country. The goal of air conditioning is to provide a more comfortable interior environment compared to the exterior environment or outdoor typically for human and animal.

On July 17, 1902, the first modern air conditioning system was invented by a 25 years old engineer named Willis Carrier from New York. At that time, Carrier is tasked to find a solution for the production problem at the Sackett & Wilhelms Lithography and Printing Company in Brooklyn, New York. The problem began with the paper affected by excessive humidity in the printing company where the paper stock was expanding and contracting during printing and caused misaligned, poor quality and waste production days. By 1903, Carrier designed a system of chiller coils to maintain a constant and comfortable humidity of 55% year-round to Sackett & Wilhelms printing plant. The modern air conditioning was born. (Weathermakers of The World, n.d.)

Over the years, global demand for air conditioning is dramatically rose. Air conditioning had become a basic necessary equipment or “needs” instead of what being desired or “wants” as a results of climate change (global temperature increase) and air pollutions. However, air conditioning equipment make a major contribution to

the global warming or greenhouse effect caused by the emissions of fluorine such as HFCs and HCFCs contained in refrigerant through venting and leakages of refrigerant. Qing (2013) from University of Waterloo argues that chlorofluorocarbon (CFCs) is to be blame for global warming since 1970s and not carbon dioxide (CO_2) according to a published by International Journal of Modern Physics B. In addition, the operation of air conditioner consumes a large amount of electricity generated mostly by burning fossil fuels and as such makes contribution to the global warming and air pollution due to the additional of carbon emissions.

Refrigerant R410A has been widely used in air conditioning system for the past decade in Malaysia, especially in split type air conditioner. R410A is a non-ozone depleting refrigerant as it has zero (0) ozone depletion potential (ODP), however it has significant global warming potential (GWP) of 2088. The high GWP of R410A has been concerned as it attributed to the global warming. As a result, refrigerant R32 is used to replace R410A as they both have some similar properties and characteristics. R32 has zero (0) ODP and a relatively low GWP of 675, which is 1413 or equivalent to 68% lesser than R410A.

1.1 Problem Statement

Global warming was one of the most concern issues worldwide since the past few decades. Refrigeration technologies can be a part of solution for mitigating global warming; but it also contributes to the global warming potential (GWP) directly through equipment leakages or venting deliberately and indirectly through high consumption of electricity generated by burning fossil fuels. Many efforts have been made to minimize the global warming including developing of new refrigerant that have lower GWP - R32. However, there is only limited information or studies and analysis did by previous researcher on refrigerant R32 as it is a newly developed refrigerant. Some researchers claimed that R32 has better behaviour than R410A due to its low GWP and better performances such as energy efficiency. In this research, validation of the performance of R32 is to be study and analyse to collate with the

current R410A refrigerant to ensure it is not only has low GWP but crown in its overall performances including energy efficiency, cost effectiveness, safety and other factors.

1.2 Objectives

The objective in this project is to collate the operating conditions including the energy consumption, temperatures and pressures of both split type air conditioner using two different types of refrigerant which is R410A and R32 under standard conditions. Besides that, the coefficient of performance (COP) of both split air conditioners using two different refrigerants (R410A and R32) is to be determined.

1.3 Scope

Refrigerant are widely used in a variety of heating, ventilating, air conditioning and refrigeration (HVAC&R) equipment. However in this report, I will only focus primarily on the cooling performance of both 1HP (horsepower) domestic split type room air conditioners (wall mounted) which equipped with two different types of refrigerant R410A and R32. Parameters like temperatures, both discharge and suction pressures, energy consumption and coefficient of performance (COP) of the both the air conditioning units are to be determined. A minimum running time of an hour of the system is necessary to ensure the operation is stable before any data collected.

1.4 Organization

This project is organized into five main chapters. First chapter is the general introduction of the study. This chapter will briefly discuss about the background of this research, describes the problem faced which motivated this study, setting the objectives of this research and the scope of the project. Second chapter is the literature review. In this chapter, it provides previous studies or research develop from various sources which relevant and similar to the research to support the topic. Next,

methodology in the third chapter will explain the methods and principles applied in this research including the devices or equipment used and software in aiding the analysis on the next chapters. Follow by the fourth chapter, results and discussion. In this chapter, the research output of the analysis and discussion on the results with relevant chart or table attach manually or by the aid of software will be presented. At last but not least, the conclusion of the research and recommendation will be made in the last chapter, chapter five.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Chapter Two – Literature Review discussed about the published information in particular related to the topic of research involved in this study. As defined by Concordia University, literature review is a "written overview of major writings and other sources on a selected topic. Sources covered in the review may include scholarly journal articles, book, government reports, Web sites, etc. The literature review provides a description, summary and evaluation of each source". This chapter is done based on scholarly articles, journals, books and online sources which relevant to the field of study. The purpose of this chapter is to offer an overview of the significant literature published from various sources which relevant and similar to the research to support the topic.

2.1 Operation of Air Conditioning System

Air conditioning is a treatment of air so as to simultaneously control its temperature, humid moisture content, quality and circulation as required by occupants in thermal comfort (Ramgopal, n.d.). An air conditioning system provides thermal comfort to a space through removing of heat from the condition space to the surrounding or ambient. An air conditioning system comprises four essential components. They are compressor (heart of the air conditioning system), expansion valve (metering device), condenser and evaporator (heat exchanger). The air conditioning system will not be work if any of the components is absent.

2.1.1 Vapour Compression Cycle

Cooling or refrigeration is a process of moving heat (thermal energy) from a colder region to a warmer region. Refrigeration system is a combination of interconnected refrigerant containing devices in which the refrigerant is circulated for the purpose of extracting heat to produce cooling (Gupton, G. W., 2002). The most common or widely used method of cooling is vapour compression cycles. Vapour compression cycles uses four main components of the air conditioning system (compressor, condenser, expansion valve and evaporator) to produce cooling effect.

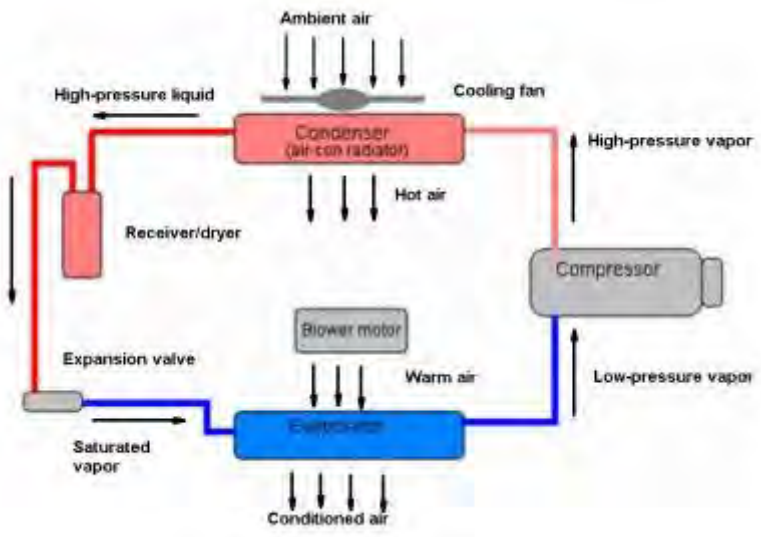

Figure 2.1: Vapour Compression Cycle

In vapour compression cycles, the refrigerant undergoes pressure, temperature and phase changes. The system starts with the compressor where circulating refrigerant vapour is compressed which entered via the suction line. The high pressure and high temperature refrigerant vapour after compression and then entered to the condenser (heat exchanger) via the discharge line. The high temperature refrigerant vapour loses it heat to the surrounding air by the help of a condenser fan which increase the air flow through the condenser for a higher efficiency of heat transfer. At this point, the refrigerant is cooled and condensed to low temperature in liquid state known as “saturated liquid”. The expansion valve regulates the liquid refrigerant flow to a proper and required amount into the evaporator. In the expansion valve, the flow of high pressure

liquid refrigerant is restricted and causes a pressure drop at the exit of the valve. This drastically drop in pressure causes the temperature of the refrigerant drops to an extremely cool temperature. The low pressure and low temperature liquid refrigerant is then entered to the evaporator. The blower will force the air in the conditioned space across the evaporator coil, heat transfer happens where the heat in the air transferred into the refrigerant. The liquid refrigerant boils or evaporates to "saturated vapour" in the evaporator as it absorbs heat from the surrounding air. The low pressure vapour refrigerant is then return to the compressor and the cycle is repeated.

Heating is a process of supplying heat to a room or building by a system used to do so (Oxford Dictionary, 2010). A heating system provides warmth or thermal comfort through supplying heat from a heat source to a conditioned space. In four season countries, heating devices is very important as an air conditioning system to provide thermal comfort in a room or building from freezing cold weather during winter. Vapour compression cycle can produce heating too other than just cooling. By reversing the flow of refrigerant in the vapour compression cycle, it can produce heating to the conditioned space. A reversing valve can be switched to change from cooling to heating or vice versa claimed by Weston (1992). This allows cooling and heating to achieve in a single system.

2.2 Classification of Air Conditioning System

There is various type of air conditioning system available in the market currently. Air conditioning system can be classified into three categories corresponding to their related equipment, which are individual systems, unitary packaged systems and centralized systems (Dani, 2008). Each type of system serves its own purpose and based on its suitability of usage for different applications and optimum performance. The selection of an air conditioning system should consider several criteria which likely to perform as desired. Criteria to be considered include performance requirements, capacity requirements, architectural constrain, energy consumption and spatial requirement.

2.2.1 Individual Systems

An individual air conditioning system usually utilize either a single, self-contained (assembled by factory and ready to use), packaged room air conditioner (window air conditioner) or separated indoor and outdoor units (split air conditioner) often used to condition an individual room. (Wang & Lavan, 1999). Individual system is small in size, easy to install, and the control is simple for individual room. However, individual system only can serve a limited space or a small area.

2.2.2 Unitary Packaged Systems

In package air conditioning system, the compressor, evaporator, blower and air filter are all fitted in one single cabinet and assembled at the factory location. It is usually is placed on a roof or on a concrete slab next to the house's foundation. This type of air conditioner is used in small commercial buildings. The conditioned air is normally transferred though ducting which is usually hidden in the ceiling or wall of the building. Air supply and return ducts come from indoors through the home's exterior wall or roof to connect with the packaged air conditioner, which is usually located outdoors. Unitary packages system can divide into two types, one with air cooled condenser and one with water cooled condenser depends to the capacity required and spatial availability.

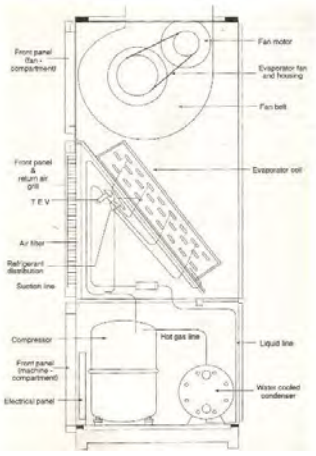

Figure 2.2: Example of unitary packages system

2.2.3 Centralized Systems

Centralized air conditioning systems are used when large buildings comprising of several floors such as hotels, theatres, airports and shopping malls are to be air conditioned completely. There are two type of cooling method in centralized system, direct expansion (DX) and using central chilled water system (CCWS). In direct expansion system, refrigerant is directly used to cool the conditioned room air, whereas in chilled water system the refrigerant first chills the water, which in turn chills the room air. In central chilled water system, the water is chilled to very low temperature by the chiller. The chilled water is then pumped to the Air Handling Unit (AHU), the chilled water will absorb the heat from the conditioned space through the return air forced across the evaporator coil by a blower in the AHU. The conditioned air is then flow to the entire building via ducts.

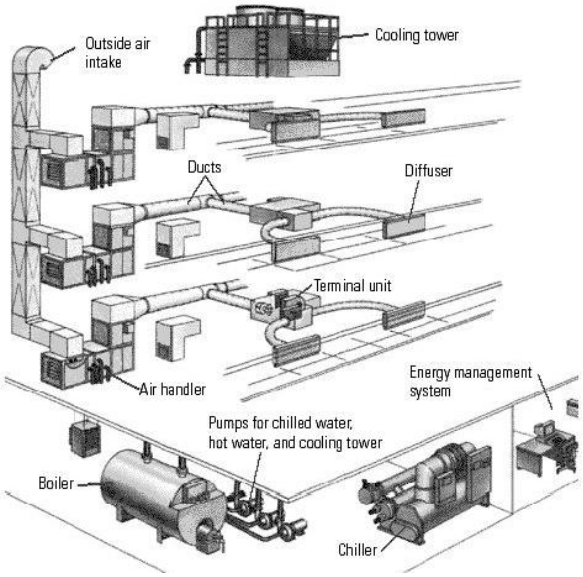

Figure 2.3: Example of centralized unit

2.3 Type of Individual Systems

2.3.1 Split Air Conditioning System

Split air conditioner is popular for their high-efficiency cooling performance. It is comprises of two basic parts, the indoor unit and outdoor unit. The indoor unit, fitted inside the room or house, comprises the evaporator or cooling coil and the blower. The outdoor unit, fitted outside the room (outdoor) or house, comprises the compressor, condenser and expansion valve. Split air conditioners typically found in residential or small commercial buildings which can be wall mounted, ceiling mounted and floor mounted. Airedale Cooling Services Ltd (2015) posted a finding of difference between wall mounted and floor mounted air conditioning, wall and ceiling mounted split air conditioner normally takes longer time for occupant to feel the benefit. However, it will provide a good distribution of conditioned air throughout the space as cool air will eventually move downwards (denser) and warm air will rise upwards (less dense). On the other hand, floor mounted split air conditioner is at ground level, it takes less time for occupant to feel the benefit as occupant is closer proximity to it. Floor mounted is usually used when there is an architectural constrain where no solid wall available for appliances attachment. Example of drawback is furniture will cause blockage of air flow from distribute evenly throughout the space.

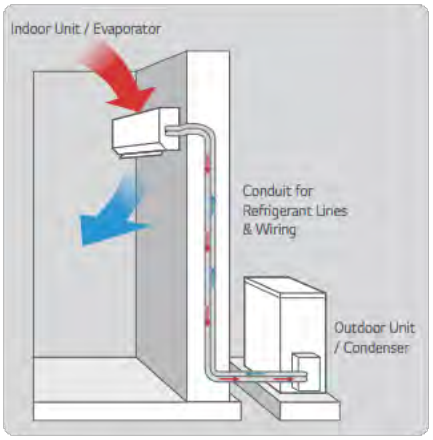

Figure 2.4: Example of wall mounted split air conditioner

2.3.2 Windows Air Conditioning System

Window air conditioners or sometimes known as room air conditioner are one of the most commonly used and cheapest types of air conditioners. All the components like the compressor, condenser, expansion valve and evaporator coil are assembled in a single casing. According to airconditioning-system.com (2011), this type of air conditioner has a double fan shaft motor with fan blades mounted on both end of the motor shaft. One fan blade is located at the condenser side, while the other one is located at the evaporator side. There is an insulated partition used to separate both of the condenser and evaporator within the same casing. It is typically installed in a window or custom opening in a wall. Window air conditioner units are reliable and simple to install to keep a room cool while avoiding costly construction. However, this system can only cool small areas and are not intended to provide cooling to multiple rooms or zones. In addition, window air conditioner units can be easily removed for storage when the summer heat dies down.

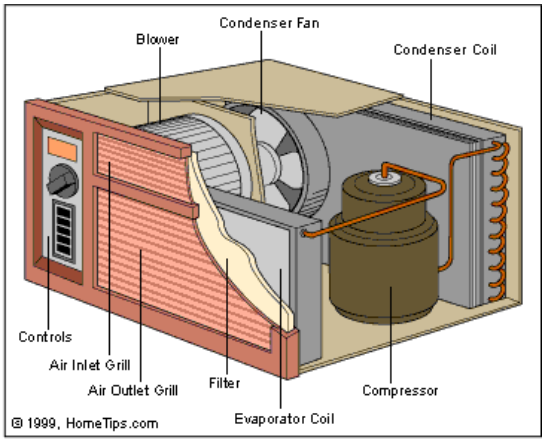

Figure 2.5: Example of window air conditioner

2.3.3 Portable Air Conditioning System

Portable air conditioner (PAC) is a self-contained portable system ideal for cooling single rooms. It is almost similar to window air conditioner, but the whole portable air conditioner unit is sit in indoor with only a small exhaust