UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION OF MULTIPLE COOLING COIL EFFECT IN HYDRONIC RADIANT COOLING SYSTEM FOR AIR HANDLING UNIT (AHU) PURPOSES

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

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Refrigeration & Air-Conditioning Systems) (Hons.). The member of the supervisory is as follow:

……

(Mr. Amir Abdullah Bin Muhamad Damanhuri)

ABSTRAK

Unit pengendalian udara adalah alat yang digunakan untuk mengawal dan mengedarkan udara sebagai sebahagian daripada sistem "Heating, Ventilating and Air Conditioning (HVAC)". Komponen utama dalam unit pengendalian udara adalah kipas, elemen penyejukan dan pemanasan, alat pelembab, rak penapis, pengurang bunyi dan peredam. Sistem ini kebiasaannya disambungkan ke salur udara yang membekalkan udara dingin pada bangunan. Sumber penyejukan di unit pengendalian udara dihasilkan oleh sistem penyejuk yang menggunakan air dan bahan pendingin sebagai media pengangkutan. Penggunaan bahan pendingin mempunyai kesan yang ketara kepada alam sekitar dan lapisan ozon. Tambahan pula, pemampat menggunakan banyak tenaga elektrik untuk memampatkan bahan pendingin ke dalam sistem. "Hydronic Cooling Radiant (HRC)" adalah salah satu sistem alternatif yang menghasilkan air sejuk sebagai media pengangkutan. Sistem ini telah digunakan di negara-negara barat. Di samping itu, sistem ini juga boleh membantu mengurangkan penggunaan elektrik kerana ia hanya menggunakan pam untuk membekalkan air sejuk. Di unit pengendalian udara, kipas menggunakan hampir 40% daripada jumlah tenaga elektrik di dalam sistem. Oleh itu, pemilihan kipas perlu dipertimbangkan di dalam kajian semasa. Pembelajaran ini hanya memberikan tumpuan kepada prestasi unit pengendalian udara dan menerangkan kebarangkalian menggunakan sistem HRC di Malaysia. Data yang diperolehi akan diperhatikan dan dianalisis untuk mengukur prestasi dengan membandingkan parameter yang memberi kesan pada sistem unit pengendalian udara. Suhu dan kelembapan untuk mencapai keselesaan di Malaysia adalah di antara 23°C hingga 26°C dan 30% kepada 60%. Rekabentuk, fabrikasi dan eksperimen projek telah dibentangkan.

ABSTRACT

The Air Handling Unit system is a device used to control and circulate air as part of Heating, Ventilating and Air Conditioning system (HVAC).The major components in Air Handling unit are fan, cooling and heating element, humidifier, filter racks, sound attenuator and damper. The system usually connect to a ductwork that supply the conditioned air through the building. The cooling sources in Air Handling Unit are delivered by a chiller that use water and refrigerant as medium transport. The use of refrigerant had a significant impact on environment and ozone layer. Furthermore, compressor use a lot of electricity to compress a refrigerant into the system. Hydronic Radiant Cooling is an alternative system that produce cold water as a medium transport. The system has been used in western countries. In addition, the system also can help to reduce electrical consumption because it only use pump to supply cold water. In Air Handling Unit, fan use almost 40% of total electricity in the system. So that, the selection of fan must be considered .This current study focus on the performances of Air Handling Unit and describes the possibility of using Hydronic Radiant Cooling in Malaysia. The data obtained were observed and analysed to measure the performance by comparing the effective parameter in Air Handling Unit. The temperature and relative humidity for thermal comfort to be achieve in Malaysia are between 23°C to 26°C and 30% to 60%. Design, fabrication and experimental of the project are presented.

DEDICATION

To my beloved parents, Rossli Bin Yusoff and Saodah Binti OthmanI acknowledge my sincere indebtedness and gratitude to them for their love, dream and sacrifice throughout my life. I am really thankful for their sacrifice, patience, and understanding that were inevitable to make this work is possible. Their sacrifice had inspired me from the day I learned how to read and write until what I have done 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 dreams comes true 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 suggestions, which are crucial for the successful completion of this current studies.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

A	Ampere/Area
AC	Alternate Current
AHU	Air Handling Unit
C	Celsius
Cfm	Cubic feet per minute
COP	Coefficient of Performances
Cp	Specific Heat
F	Fahrenheit
Ft	Feet
Fpm	Feet per minute
HRC	Hydronic Radiant Cooling
h	Height
HVAC	Heating, Ventilating and Air Conditioning
Hz	Hertz
Inch	Inches
Kg	Kilogram
Kw	Kilowatt
L	Litre
l	Length
m	Meter
$\dot{m}$	Mass flow rate
NaC1	Sodium Chloride
PVC	Polivinyl Chloride
RH	Relative Humidity
Rpm	Rotation per minute
USB	Universal Serius Bus
Q	Heat
T_R	Temperature

V	Voltage/Velocity
W	Width
η	Efficiency
ρ	Density
$\leq$	Less than or equal to

CHAPTER 1

INTRODUCTION

The current chapter introduces the most important subtitles related to the project. However, the subtitles are the plan and the basic topics, which include background of the study, problem statement, objectives, scope of the project and thesis outline.

1.1 Background of the study

Air-conditioning is the process of treating the temperature, relative humidity, provide clean air and distribute it into the building space. In thousand years ago, several ancient architectural already studies cooling technique for controlling building temperature to local climate such as thermal conductivity of material, high room ceilings and shading. The first modern air-conditioning system was created in 1902 by a 25 years old engineer named Willis Carrier. Nowadays, conventional air conditioning become an important device. It's mainly used in building over the world such as for residential, industrial and commercial. The main purpose of air-conditioning system is to provide thermal comfort and improving indoor air quality (IAQ) for occupants. The application of air conditioning in daily live allows people to feel comfortable especially in Malaysia that is known as a hot and humid climate condition. By lowering the occupied zone temperature, vapour compression cycle are commonly used in air conditioning system to achieve thermal comfort for human use (Regnier, 2012).

In recent years, a system that provide more comfortable thermal environment than conventional all-air system has been created. The system is designed to reduce energy consumption in the line with current modern technology. An alternative system is called Hydronic Radiant Cooling (HRC) which is using water as the transport medium(Colorado, 2010). It is becomes one of the significant solutions since it is able to reduce amount of air distribute in the buildings. HRC is normally install in ceiling, wall and building floor. Unlike the conventional air conditioning system, HRC does not use a vapour compression cycle that consume 40% of the total electrical consumption in the world (Westphalen, Koszalinski, & Little, 1999). Cold water are used to replace refrigerant gas as a cooling medium that is unlimited source, cheapest and also environmental friendly. The natural cooling provided by HRC is more acceptable range for thermal comfort.

In this current study, an Air Handling Unit (AHU) which are used in air-conditioning system will be design, fabricate in prototype and tested the application for cooling in Malaysia. HRC are connected to cooling coil to supply cold water as a cooling sources. Fan are required in AHU which performs the function of force and recycling the air present in the building space. The second important components of an AHU are the cooling elements which are used to allow cold water flow into the air-conditioning systems. The distance between fan and cooling coil, number of row, and oriental of the design must be considered because it will affect the AHU performances (A. P. Guide et al 1998). Selection of material for AHU casing are also are important parts to prevent heat loss and the types of insulation are selected. Drain pan are attached below the cooling coil to catches the condensate that drips off at the outside of the coil as the warm moist air passes over the coil. The cold water in the coil cooled the air and causing the moisture to condense on the outside of the coil.

In fact, the characteristics of the plastic container are to keep store heat because it will minimize heat transfer due to conduction and radiation process. So that, it will be selected to ensure the ice cubing in HRC system is durable. In order to lowering the temperature as needed , salt is added to the cold water and it will cause a temperature drop that slows the melting rate and increases the freezing rate. Pump are used to force the cold water into the cooling coil. The data that will be taken in

consideration are output temperature and also relative humidity for controlling the humidity of the conditioned space. In order to control the humidity and dry bulb temperature, silica gel material is placed after cooling coil where the air inlet is supplied. Therefore, the experimental work will be carried out to confirm the suitability of this application in Malaysia.

1.2 Problem Statement

Hot climate in Malaysia led many building use air conditioning for comfort. The total energy consumption increase and cause a large impact on economy. Most of the existing air-conditioning in the market using vapour compression cycle compared to absorption cycle. Compressor is one of the basic components in the vapor compression cycle and it is assigned to compress the refrigerant into the system. It requires a high energy consumption to operate. It also generates noise and vibrations in the system that requires maintenance and this increase the annual cost.

Vapor compression cycle use a refrigerants as a medium transportation which absorb and remove heat from a space to be cooled. These can be less environmental friendly as they require refrigerants for emission. This current study is looking for an alternative source of cooling associate with AHU with less energy consumption to be assigned which focusing on Hydronic Radiant Cooling system associated with AHU is the challenge.

1.3 Objective

In this current project, some targets has been select to focus on the studied. Therefore, the main objective of the current project are:

a) To study the possibilities of using Hydronic Radiant Cooling (HRC) as an alternative cooling system for Malaysia climate

b) To develop a prototype of Air Handling Unit to apply Hydronic Radiant Cooling in achieving desired temperature

c) To compare multiple row of cooling coil in demonstrate temperature and relative humidity data by applying silica gel**.**

1.4 Scope of Work

Commercial businesses play a role at reducing costs and energy consumption through a heating, ventilation and air conditioning (HVAC). This study focus on enhancement the performances of Hydronic Radiant Cooling system in hydronic tank that has been develop. The scope of this current study is the part in AHU that includes multiple row of cooling coil and the distance between fan and cooling coils. In addition, cold water supply in container box is also will be considered. The working process only considered at enclosed place to maintain its surrounding temperature.

1.5 Thesis Outline

This report has been divided into five chapters. The chapter includes are introduction, literature review, methodology, results and analysis, conclusion and recommendation. Chapter 1 contains background of the study, problem statement, objective, and scope of work. Chapter 2 written about the previous studies and research related to this project. Chapter 3 presents the Methodology of this project which include the materials used, equipment's, fabrication, and procedures. In Chapter 4, indicates all results and discussion with analysis of the project. The result of the project has been discussed in detail within this chapter. Lastly, in chapter 5 shows the explanations about the conclusion and recommendations for future works is presented.

CHAPTER 2

LITERATURE REVIEW

Present literature review is summarized to survey topics that have more relevant to current study. The most important subtopics summarized for current Literature review are background, Air Handling Unit, fans, cooling coils, Hydronic radiant cooling system, acrylic and silica gel.

Therefore the background for current project is carried out and summarized to understand the basic idea of air conditioning system. Central air conditioning cycle is the attractive example which used in wide space. Air Conditioning and Global energy demand is considered as well.

2.1. Central Air Conditioning Cycle

Central air conditioning cycle is an air conditioning system. However, it uses a series of equipment's to distribute cooling media to exchange heat and supply conditioned air from one point to more than one rooms. Normally water is used as the cooling media for larger buildings. Central air conditioning cycle is a process of removing heat content from multiple sources in the building through a series of heat exchange equipment which ultimately remove the heat to outdoor atmosphere. Once the air is being cooled, the AHU must distribute it throughout the building. AHU supplies the cooled and dehumidified air to the conditioned space and returns it back into the facility .Cooling towers are heat rejection devices used to transfer process waste heat to the atmosphere. Cooling towers may either use the evaporation of water to reject process heat and cool the working fluid to near the wet-bulb air

temperature or rely solely on air to cool the working fluid to near the dry-bulb air temperature (Christiansen, 2007). The arrangement of Central system cycle is shown in Figure 2.1.

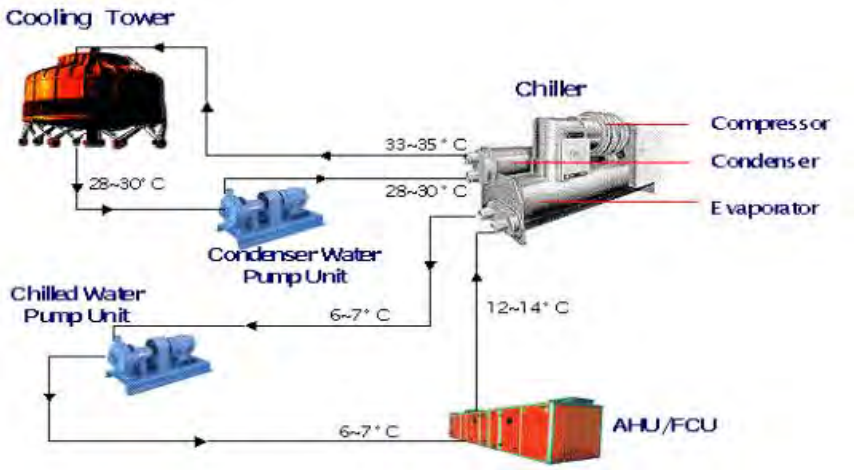

Figure 2.1: Central system cycle

2.1.1 Air Conditioning and Global energy demand

Heating, ventilating, and air conditioning (HVAC) consumes almost 31% of the total electricity compared with lighting and other applications that use electricity as a main source(Kusiak & Li, 2010). HVAC is widely used in building with hot and humid climate conditions like Malaysia. Many air conditioned spaces in largest building such as, hotel, office and shopping mall have lower temperature setting to compensate for inadequate air distribution in some areas (Yap et al., 2011). Figure 2.2 illustrates energy usage of equipment in HVAC system.

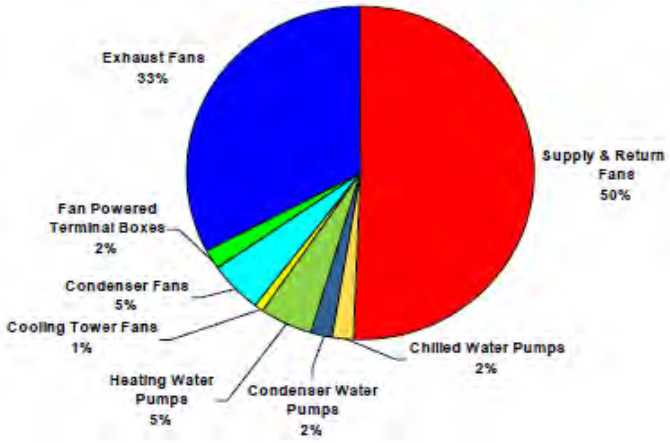

Figure 2.2: Energy usage of equipment in HVAC system

Using supply and return fans consume huge amount of energy compared to the other applications, because it used in almost 100% of system types as defined in (Westphalen et al., 1999) and as reported that. Normally, air distribution design resulting considerable pressure drop for filtration, cooling and heating coils, terminal boxes, and diffusers, and many of these fans operate at 100% power during all building operating hours

Improvements in equipment efficiency can help to reduce in building operating costs. Energy conservation in buildings is important because HVAC system is one of the primary energy users in buildings. Efficiency of AHU and air distribution systems can save amounts of energy, reduce operating costs and comply with widely used energy standards (ASHRAE Standard 90.1 2004) and building codes. The electricity sector involves the generation, transmission, and distribution of electricity. Carbon dioxide (CO_2) makes up the most of the greenhouse gas emissions from the sector, but smaller amounts of methane (CH_4) and nitrous oxide (N_2O) are also emitted. These gases are released during the combustion of fossil fuels, such as coal, oil, and natural gas, to produce electricity. Buildings produce to about 30% of the total greenhouse gases emissions, and the proportion has been increasing to the level of the developed counties (Yun et al., 2014) .