UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE EFFECT OF USING ALUMINUM SHEET FOR THERMAL COMFORT

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Refrigeration and Air-Conditioning Systems)(Hons.)

by

MOHAMAD ZULFIQKAR BIN HAMLEE
B071110404
901030-01-6539

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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 Engineering Technology (Air Conditioning and Refrigeration System) (Hons.). The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Sistem siling sejuk adalah alternatif kepada sistem penghawa dingin konvensional yang memberikan keselesaan haba untuk penghuni. Siling sejuk adalah alat yang bertanggungjawab untuk menyediakan kesan penyejukan dengan menggunakan idea Sistem Penyejukan Hidronik Beradiasi. Lembaran siling sejuk dipasang di siling dengan itu haba diserap secara olakan bebas dan radiasi. Penyejukan Hidronik Beradiasi adalah satu sistem yang menggunakan air sebagai bahan pemindahan haba dengan udara di dalam ruang dingin untuk mencapai keselesaan terma. Dalam kajian ini, untuk menyiasat suhu siling sejuk sesuai dan mengawal kelembapan relatif adalah satu cabaran yang besar untuk membuat penghuni selesa. Kerja eksperimen akan dijalankan di dalam kebuk persekitaran menggunakan siling sejuk dengan dan tanpa lembaran Aluminium. Kaedah eksperimen mempunyai kebuk perseketiaran di mana model lembaran siling sejuk dipasang di bahagian atas kebuk itu bagi mencerminkan satu model bilik khas di Malaysia. Keputusan hasil yang diukur adalah suhu bilik, suhu siling sejuk dan kelembapan relatif. Hasil daripada eksperimen, suhu yang sesuai pada siling sejuk untuk menyediakan keselesaan termal dalam ruang alam sekitar adalah daripada 5.3 kepada 6.3 ℃ ℃ di mana ia menyebabkan suhu di dalam ruang alam sekitar daripada 22.9 ℃ kepada 23.8 ℃. Ini disebabkan oleh perbezaan suhu antara panel siling sejuk dan udara dalam kebuk alam sekitar. Daripada keputusan itu, suhu yang sesuai siling sejuk boleh ditentukan untuk menyediakan keselesaan termal dalam ruang alam sekitar.

ABSTRACT

Chilled Ceiling System is an alternative to conventional air conditioning system that provides thermal comfort to the occupant. Chilled ceiling is a device responsible for providing cooling effect by using Hydronic Radiant Cooling idea. Chilled ceiling panel is installed at the ceiling thus absorbed heat by natural convection and radiation. Hydronic Radiant Cooling is a system that used water as a heat medium transfer with air inside the conditioned space to achieve thermal comfort. In this study, to investigate appropriate chilled ceiling temperature and controlling relative humidity is a great challenge to make occupants comfortable. Experimental work will be conducted in the environment chamber using chilled ceiling with and without Aluminum sheet. The experimental method features an environmental chamber where the chilled ceiling panel model installed at the top of the chamber to develop a model of a typical room in Malaysia. The outcome parameters are room temperature, chilled ceiling temperature and relative humidity. As the result of the experiment, the appropriate temperature at the chilled ceiling to provide thermal comfort in the environmental chamber is from 5.3℃ to 6.3℃ where is cause the temperature in the environmental chamber from 22.9℃ to 23.8℃. This is due to temperature difference between chilled ceiling panel and the air in the environmental chamber. From the result, the appropriate temperature of the chilled ceiling can be determined to provide thermal comfort in the environmental chamber.

DEDICATION

To my father Hamlee Bin Hamzah, my mother, Siti Noorhayati Binti Mohamad Noordin, my brother and sister and also my friend who is classmate and also housemate. Lastly to my supervisor Dr Ahmed Salem Saeed Bin Ghooth for supporting me throughout this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

NaCl	-	Sodium Chloride
HRC	-	Hydronic Radiant Cooling System
ASHRAE	-	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CFD	-	Computational Fluid Dynamics
ANSYS	-	Engineering Simulation Software
VAV	-	Variable Air Volume
R_H	-	Relative Humidity
T_{CC}	-	Chilled Ceiling Temperature
T_W	-	Water Temperature
T_R	-	Room Temperature
%	-	Percentage
℃	-	Celsius
°F	-	Fahrenheit
g	-	Gram
m	-	Meter
kg	-	Kilogram
PMV	-	Predicted Mean Vote

CHAPTER 1

INTRODUCTION

In this chapter will introduce the project background, problem statement, objective and scope based on the research of this paper. Organization of thesis is included as well.

1.0 Background

There are several benefits can be obtained by using air conditioner and it also becomes very important in our daily life for reaching thermal comfort. In the most time in Malaysia, the temperature rises up to 40 degree Celsius in the summer season. As a hot humid country, this matter response to loss of water and salt from human body caused of heavy sweating and feeling discomfort. This matter also affects the human healthiness due to the high temperature exposure and can cause to falling sick. The examples of illness that may occur when someone is expose to the high temperature such as headache, dizziness, weakness, thirst, and irritability. Air conditioner become as an important device due to overcome discomfort problems, by providing cooling to occupied zone to make human comfortable and also it can improve job performance of human. At the same time, it is also preventing occupant from illness that associated. Although air conditioning is very convenient, some

limitations associated with, such as high energy consumption. Conventional air conditioning system is energy intensive especially in hot humid climates due to bring the air temperature below it is dew point temperature to overcome excessive humidity and need to overcome high cooling load. This is because conventional air conditioning system used vapor compression to provide cooling effect. Vapor compression cycle consumes extra energy to overcome the cooling load from the conditioned space. The purpose of this research is to find an alternative solution to reduce energy intensive of air conditioning system. The possibility that be considered in this research is to replace conventional air conditioning system with Hydronic Radiant Cooling System.

Hydronic Radiant Cooling System provides cooling to the conditioned space by absorbing the heat from the room and transfers it into the liquid circulation in the copper tube installed at the ceiling. The copper tubes are installed at the ceiling of the conditioned space called radiant ceiling. There is a small difference in the purpose of using radiant ceiling either for heating or cooling, depending on the cold or hot water use. The Radiant Ceiling Panel is a device can be formed by installing some Aluminum sheet over the copper tubes. It is more efficient to install at the floor for heating purpose, while with cooling purpose the Radiant Ceiling Panel is suitable to be installed at the ceiling. This is due to the characteristic of nature air heat movement. In the nature, the layers of heavy air density will move downward while the low air density upward. This can be seen within closed space and without any influence of others factors. Normally, the heat medium transfer used in Hydronic Radiant Cooling System is water. Most of the reason is due to the safety factor of leaking probability which is not brought hazardous to the occupant.

As mentioned earlier, unlike conventional air-conditioning systems that rely on vapor compression, a typical Hydronic Radiant Cooling (HRC) system that considered as an alternative system named Chilled Ceiling System. Chilled Ceiling System would be used for product preservation and providing thermal comfort. Experimental work will be carried out to test the possibility of using HRC for Malaysian climate. Temperature for chilled ceiling panels will be measured depending on water supplied temperature. The indoor temperature will be record and cooling capacity will be test with and without of using Aluminum sheet. While, the dry air introduced the environment chamber will be provided via using Silica Gel materials in the entrance of the air supply.

1.1 Problem statement

In Malaysia air conditioning system is used almost at all residences. As it relies on vapor compression system that is called traditional air conditioning system. This traditional air conditioning system is energy intensive in order to provide thermal comfort. Although the alternative solution to traditional air conditioning system is chilled ceiling system, overcome the cooling load is the major problem encountered chilled ceiling in humid climate like Malaysia. The issue of this research is to invent an alternative of vapor compression system in Malaysia. The alternative vapor compression system designed is Chilled Ceiling system.

1.2 Objective

The expectation result by this project is to achieve the objectives of the current research in order to give benefit to the consumer or other researchers. The main objectives in this research are:

a) To ensure the possibility of accepting in Malaysia by achieving thermal comfort in environmental chamber by design a Chilled Ceiling System as Hydronic Cooling System.
b) To investigate appropriate chilled ceiling temperature and controlling relative humidity.

1.3 Scope

In this research, the data collected will be obtained from the experimental work conducted. In order to determine the possibility of accepting Chilled Ceiling System, this experiment will be conducted in Melacca, Malaysia. Our consideration of this research will focus inside of the environmental chamber. Especially the temperature and relative humidity inside the environmental chamber need to be considered. Since Malaysia is a hot humid climates country, the system will be designed to use only for cooling purpose. This experiment will adopt appropriate solution to control the temperature of the water in the chiller. Besides that, the value of relative humidity will be controlled by varying the amounts of Silica Gel to avoid condensation occur at the surface of chilled ceiling. Lastly, the experiment will be conducted by measuring the indoor temperature without or with aluminum sheet that installed at the Chilled Ceiling Radiant Panel.

1.4 Organization of the thesis

In the chapter 1 will address some introduction of the title of this research. Also the problem faced and the objectives that need to achieve guided by the limitations fixed. Scope and organization of the thesis are included in this chapter as well. This project will address about past works published in open literature related to the current research at the chapter 2. The finding of the previous studies related to this research will be writing down on this chapter. Chapter 3 describes the methodology used to complete the experiment besides to achieve the objectives. The materials, equipments and procedures are presented as well. Meanwhile, results and finding gained of the research are discussed in the chapter 4. The results of the research in tables, figure, drawings and graph will be presented at this chapter. Further observation of the discussion on the result will be included. Chapter 5 will conclude on overall of the research in the effect of Aluminum sheet on chilled ceiling for thermal comfort. This chapter also will deliver some recommendation due to the result obtained. Several suggestions associated lead to future researcher also provided to create an opportunity of using Hydronic Radiant Cooling System in Malaysia.

CHAPTER 2

LITERATURE REVIEW

In this chapter presenting on the previous studies related on this research in order to ensure the flow of the research smooth in designing Chilled Ceiling System and achieving research objective. The strategy of this chapter is to understand the concept related to the Hydronic Radiant Cooling system.

2.0 Introduction

Previous study research is most important thing in purpose of innovation of current technology. This previous study also can be called as literature reviewed which is gather the information related to the current research. This will help the researcher in the selection of material, comparison between component and device, and take the advantage from the previous study. In this section will be listed previous study related to topic of this research.

2.1 Air conditioning

Air conditioning is a process of providing comfort air by controlling simultaneously its temperature, humidity and quality of the air to the conditioned

space (Green & Perry, AIR CONDITIONING, 2008). This conditioned air is treating by using air conditioning system. Air conditioning system is a combination of several components due to control this parameter. The arrangement in the air conditioning system is according to the function of the component to perform a given task. Air conditioning system is required due to provide the comfortable thermal environment by controlling the sufficient amount of moisture in the air. Air conditioning system also able to removes contaminant particle or gases in the air. In other word, air conditioning it is associated with human comfort in the conditioned space. This comfort is important to increase working productivity and human health.

2.2 Chilled ceiling system

Chilled ceiling is a system that provides cooling effect to the occupants by using Hydronic Radiant cooling system. In the other word, Chilled ceiling system is an air conditioning system that is provides thermal comfort in the conditioned space. This system is relatively new in Malaysia and the other locations that are hot humid climates. Since the middle of 1980s, this system has been used in Europe country (Virta, 2004). In other hand, hydronic radiant cooling is a system that used water as a heat medium transfer with air within a space in order to achieve thermal comfort. This chilled ceiling system applied combination of natural convection and radiation (Castillo and Tovar, 2012; Diaz, 2011). The benefits of chilled ceiling system are consuming low energy consumption compared to vapor compression system. This can be proved because radiant ceiling systems are able to reduce the energy consumption by decreased air volume flow rate and increasing evaporating temperature (Niu et al., 2002). This related matter able to decrease the energy of fan

and also the energy of chiller. Besides that, cooling capacity can be decreased over 17% under of using mixed convection and radiation by using chilled ceiling system (Jeong and Mumma, 2007). Furthermore, chilled ceiling system able to provided high indoor air quality when 100% of the fresh air will be supplied to the conditioned space.

2.2.1 Radiant cooling panel

Radiant cooling panel can be used in residential, commercial institutional or industrial buildings. Radiant cooling panel is normally is a flat surface consist of copper tube in a serpentine shaped. This panel can be located at the ceiling, floor or wall according to the purpose of the usage.

As known, heat is energy and energy cannot be destroyed but can be transfer. Heat is moving from when temperature difference appeared. Thus, heat will transferred from high temperature region to low temperature region. Due to this situation, cooling element must be located inside of the conditioned space to absorb heat in the closed area and remove it to the other places. This is why the Radiant Cooling Panel is located inside of the conditioned space. The idea is to flowing cooling medium (cooled water) through the radiant cooling panel. This cooling medium will absorb heat from the conditioned space and remove the heat outside of the conditioned space by using heat exchanger. According to Watson, (2002) in order to create an environment that absorbing heat rather than emission heat, the radiant cooling panel must be at a lower surface temperature than the surrounding spaces.

In the predicted problem, which is condensation appeared at the surface of the panel. This is cause of the radiant cooling panel surface temperature lower than the dew point temperature of the air in the room (Watson, 2002). The point can be describe when the moisture in the air is sufficient then contact with the cold surface and water will be seen appeared on the surface. The problem associated potential occurs in hot humid climates such as Malaysia. Large numbers of condensation happened in the conditioned space will be able to ruin interior furnishing. Considering the dew point of the occupied space and the temperature of the radiant cooling panel it is the most of important thing to designing Chilled Ceiling Panel.

2.2.1.1 Aluminum sheet

The function of the chilled panel located in the conditioned space is to absorb heat containing in the air. The rate of heat transfer between the water in the copper tube and the surrounding air is according to the area of contact surface. The area without installing aluminum sheet at the chilled panel will be smaller than without aluminum sheet. This is shows that installing aluminum sheet is to increase the area of contact surface between two medium transfer. This also shows that increasing the area of contact surface will be increase the cooling capacity of the chilled panel. In order to increase area of the contact surface, aluminum sheet is used because it is high thermal conductivity and resistant to corrosion. Aluminum is in the consideration because of the properties of the material is strength with light weight, corrosion resistance, non-toxicity and easy machinability of formability (Bralla, 1999).

2.2.2 Potential benefits of cooling energy consumption

One of the objective this research in to reduce energy consumption of using air conditioning in Malaysia by provide an alternative system to replace conventional air conditioning system. On the literature reviewed associated with the title of this research, there is potential benefits on reducing energy consumption on the employing of radiant panel cooling. In the North America, comparison of energy consumption between radiant panel cooling and conventional all-air VAV system was conducted (Stetiu, 1999). The result obtained in this research present that radiant panel cooling might save 30% of overall cooling energy. This result represent for applications across a range in North America climates. The same research also remark that potential energy savings would be achieve in range approximately 17% for cooling purpose in humid regions and 42% for heating purpose in arid regions. This issue shows that in humid regions containing larger amount of latent load which is required the same dehumidification for both systems. Furthermore, there is smaller sensible load contained in the cool regions. In the cool but very humid regions, the sensible cooling of using radiant system is smallest relative to the total cooling load but containing larger latent load. Conversely with hot and dry climates where the total cooling loads containing large amount of sensible rather than latent.

2.3 Thermal comfort

The reason of designing an air conditioning system is to provide cooled air to the conditioned space. This happened because of unsatisfied indoor temperature related to the occupant. The sufficient temperature that provides satisfaction to occupant called thermal comfort. According to American society of heating