UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF CHILLED FLOOR SYSTEM FOR COOLING IN MALAYSIA

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

by

MUHAMMAD NAJIB BIN AZIZ

B071210417

901113146196

FACULTY OF ENGINEERING TECHNOLOGY

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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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 & Air-Conditioning Systems) (Hons.). The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRACT

This project is based on one of the Hydronic Radiant Cooling (HRC) type systems that are Chilled Floor System. This project basically based on the limitation occurring of using the conventional air conditioning such as high utility bills and damage environment. Therefore, by applying Hydronic Radiant Cooling System, the limitation that occurs from conventional air conditional can be dealt. Overall of this project are focusing on measuring the room temperature and humidity inside the environmental chamber. The varied number of copper tube is installed to extend the height of cooling inside the environmental chamber. In additional, by closed the entire ventilation hole on the environmental chamber has been done to keep the heat inside, and small fan been installed at the floor of the chamber to extend the cooling height. The copper tube for chilled floor panel is covered with aluminium sheet during this experiment to increase cooling capacity and silica gel is placed at the air supply entrance to absorb the air moisture from outside before entering the chamber. Chilled water from mini chiller are pumped and circulated inside chilled floor panel through copper tubes. The temperatures in the mini chiller are considered by mixing of water, ice, sodium chloride (salt) and propylene glycol ($C_3H_8O_2$) with different ratio. The main purpose of this project is to consider of using Chilled Floor as cooling alternative in Malaysia for thermal comfort and to preserve food product. Lastly, by the end of this experiment, the minimum temperature achieved by water chilled inside the mini chiller is -18°C, while 14°C for the temperature inside the environmental chamber.

ABSTRAK

Projek ini adalah salah satu daripada sistem Penyejukan Kitaran Hydro (HRC)' iaitu sistem lantai sejuk. Secara amnya Projek ini berdasarkan kekurangan yang berlaku jika menggunakan penyaman udara konvensional antaranya ialan bil utiliti yang tinggi dan merosakkan alam sekitar. Oleh itu, dengan mengaplikasi system Penyejukan Kitaran Hydro, kekurangan yang berlaku daripada penyaman udara konvensional dapat ditangani. Secara keseluruhan, projek ini memfokuskan pengukuran suhu bilik dan kelembapan di dalam ruangan kerja. Bilangan tiub kuprum yang di pasang di dalam ruangan kerja akan diubah ubah untuk meningkatkan had ketingggian suhu. Sebagai tambahan, semua salur udara yang terdapat pada ruangan kerja ditutup bagi menyimpan suhu sejuk, dan kipas dipasang pada lantai ruangan kerja bagi menolak udara sejuk ke atas. Panel lantai sejuk di liputi dengan aluminium semasa eksperimen bagi meningkatkan kemampuan penyejukan dan gel silika ditempatkan di saluran masuk udara untuk memerangkap kelembapan udara dari luar daripada masuk ke dalam ruangan. Air sejuk daripada chiller mini akan dipam dan disebarkan ke panel lantai sejuk melalui tiub kuprum. Suhu chiller mini adalah dengan campuran air, ais, sodium klorida (garam) dan propelina glikol($C_3H_8O_2$) dengan nisbah yang berlainan. Tujuan utama projek ini adalah untuk mempertimbangkan penggunaan sistem lantai sejuk sebagai penyejuk alternatif di Malaysia untuk keselesaan dan penjagaan produk makanan. Di akhir kajian ini, suhu minimum yang dapat dicapai oleh air sejuk di dalam chiller mini adalah -18°C, manakala 14°C bagi suhu ruang kerja.

DEDICATION

I dedicate this project to my beloved parents, Aziz bin Ariffin and Hafizah binti Hussin and also to my siblings and my fiancé who always love me, support and prayed for my success. I also dedicate all my hard work and effort for this project to my supervisor Dr. Ahmed Salem Saeed Bin Ghooth for supporting me throughout this project.

Lastly, I dedicate this project to my lecturers and friends who becomes my references and always keep support me through this final year project. I will always appreciate all helps comes from them during this project was done.

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I would like to grab this chance to express my appreciation and thanks to my friends who have shared some knowledge to me in the completion of this report. Their entire companion is truly appreciated as it was a great pleasure to know them Great deals appreciated go to the contribution of my faculty of Engineering Technology (FTK). Last but not least I would like to thank my family especially my beloved parents for all support.

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q_c,	-	Heat transfer by convection (W/m 2)
α_c,	-	Convective coefficient (W/m 2 K)
T_{air},	-	Room air temperature (°C)
$T_{Surface}$,	-	Surface temperature (°C)
q_r,	-	Heat transfer by radiation (W/m 2)
σ ,	-	Stephan-Bolzmann constant (W/m 2 K 4)
T_r,	-	Mean radiant temperature of an unconditioned surface (K)
T_p,	-	Mean radiant temperature of a cooled surface (K)
F_a,	-	Configuration factor (-)
F_ε,	-	Emissivity factor (-)
q_{tot},	-	Sum of convective and radiant heat coefficient (W/m 2 K).

CHAPTER 1
INTRODUCTION

In this chapter, introduction of the most important topics that involve background, problems statement, objectives, scope of the project are provided and the thesis organization of overall chapters is provided within the chapter as well.

1.1 Project Background

Air-conditioning is the process of treating the temperature, relative humidity, cleanliness and distribution of air to the conditioned space. Many years ago, some ancient architectural already practiced cooling techniques for controlling building temperature to local climate condition such as high thermal wall, high room ceilings and shading. The primary modern air-conditioning system was developed in 1902 by a young electrical engineer named Willis Carrier.

Now a day's use of conventional air conditioning becomes very important, it has been used in many aspects of the life over the world such as for residential, industrial and commercial. The main purpose of this system is to provide thermal comfort and improving indoor air quality (IAQ) for occupants. Significantly, the application of air-conditioning in daily live allows people to feel comfortable especially in Malaysia that is known as a hot and humid zone due to achievement the thermal comfort for human body, via lowering the occupied zoned temperature by commonly vapour compression system.

Normally, people are spending 90% of their days indoors (inside the office or house). That shows the acceptable and appropriate temperature is very important for occupants to get better thermal comfort. Ventilation is also improves indoor air quality. Although air conditioning is very convenient, some limitations are associated, such as high utility bills cause of using a compressor, the refrigerant also contains chemicals cause to damage the environment and ozone layer, the air circulation can transmit infectious bacteria and allergic reactions cause by airborne dust and fungi that only circulating inside the zone, too long spent time in conditioned space will result skin drought cause by humidity decreases, and the temperature provided is only for human comfort does not suitable for preserving fresh food.

In point of fact, a practical system that creates a more comfortable thermal environment than conventional all-air systems with low energy consumption would be built in the line with current modern technology. An alternative system names a Hydronic radiant cooling (HRC) system which is using water as the transport medium becomes one of the significant solutions since it is able to reduce the amount of air distribute through the buildings, as 100% ventilation is provided by outside air system without recirculating air fraction. HRC is divided into 3 types, which are chilled ceiling, chilled wall and chilled floor system. Unlike the conventional air conditioning, Hydronic Radiant Cooling (HRC) system does not us a vapour compression cycle that consume 70% of the total electrical consumption in the world, as using water to replace refrigerant gas as a cooling medium that is unlimited source, cheap and also environmental friendly. The natural cooling provided by HRC is more acceptable range for thermal comfort.

In this project study, Chilled Floor System is designed, fabricated a prototype and tested the application for cooling in Malaysia. Floor chilled panel with Aluminum sheet, which are installed at the floor is cooled by using water circulation system via mixing the water, ice and glycol as cooling medium to lower the zone temperature. The main parameters that recorded in consideration are temperature of the zone for human comfort and preserving large amount of food product, and also relative humidity for controlling the humidity of the required zone. The air flow will

examine to be forced in order to raise an extended the height of cooling zone by using either exhaust or supply fan. In order to control the humidity and dry air temperature, Silica Gel material is placed at the entrance of the environmental chamber where the air inlet is supplied. Therefore, the experimental work is carried out to confirm the suitability of this application in Malaysia.

1.2 Problem Statement

Based on the limitation of the conventional air conditioning stated above such as high utility bills and damage environment, there are several alternative ways has been proposed, and one of the ideas is replace the conventional air conditioning system with HRC system. In this project, the major idea is to design of the floor chilled system to provide certain cooling for preserving some fresh fruits and flowers with extend distance for cooling from the floor is a challenge in case of using chilled floor system with appropriate number of tubes and ventilation.

1.3 Project Objective

In order to say the project is successful done, the objectives have been declared, and must be achieved in completing the project. The most important objectives of the current project are to:-

1. Consider the possibility of accepting chilled floor system as an alternative cooling system for Malaysia.

2. Preserve large amount of fruits, vegetables and flowers.

1.4 Project Scope

In this project, the area of consideration is environmental chamber. Temperature and relative humidity will be measured inside the environmental chamber. Temperature will be measured and recorded in several positions or height to achieve human thermal comfort temperature based on the ASHRAE guideline recommended which is 23°C to 26°C for room temperature (TR) and 30% to 60% for relative humidity (RH) by varying the number of the cooper tubes, varying the configuration of air inlet and air outlet to achieve appropriate extend distance. The fabrication of the prototype made of plywood as the environmental chamber. The silica gel is place at the air entrance inside of the environmental chamber. For the chilled floor panel, the copper tube is covered with Aluminium sheet during this experiment to increase cooling capacity. Water temperature in the mini chiller will be considered by mixing the water with ice and glycol.

1.5 Thesis Outline

The development for a Chilled Floor System contains and elaborates specific topics like introduction, literature reviews, methodology, result and analysis, conclusion, and recommendation for future work. Chapter 1 contains introduction, objectives, scope of project, project limitation and problem statement. Chapter 2 describes about the previous studies and research that relevant to the project. Chapter 3 presents the research methodology used in this project. Chapter 4 indicates all results and discussion with analysis. Chapter 5 shows the most important conclusion and recommendation for future work.

CHAPTER 2
LITERATURE REVIEW

The review in this chapter focuses on a specific survey related to brief introduction, conventional air-conditioning system, refrigerator and preserving process, hydronic radiant cooling system, thermal comfort, and ventilation. Additionally, the current study intends to investigate the possibility of using the HRC system in Malaysia.

2.1 Introduction

Hydronic Radiant Cooling (HRC) system is a new system compared to the conventional air conditioning due to HRC system does not rely on the vapor compression cycle to generate cooling effect (Lawrence Berkeley, 2004). Nowadays it can be said there are three major types of HRC system commonly used for cooling purpose such as chilled radiant ceiling, chilled radiant floor and chilled radiant wall systems. Malaysia is classified as a hot-humid zone due to the location, that is encourages us to investigate an alternative cooling system (ANSI/ASHRAE/IESNA Standard 90.1-2007). The theories and findings associated with the previous studies are reviewed and described to gain the highlight knowledge associated with the proposed current study.

2.2 Conventional Air-Conditioning System

Recent studies reported that air-conditioning can be recognized by the methods of how they conduct cooling process in the conditioned space (Beaty and Fink, 2013). In Malaysia currently, most of air-conditioning used is conventional air-conditioning while the applications of hydronic radiant cooling system is still not very popular. Conventional air-conditioning typically relies on vapor compression. Recirculate air is important in conventional air-conditioning system in order to maintain the temperature difference between supply air and room air so that it is in comfort range (Feutsel and Stetiu, 1995). Even though this air-conditioning is still providing comfort toward people but the use of refrigerant for providing cooling effect has its own side-defects. For examples, global warming and ozone depletion are caused by chlorofluorocarbons (CFC) and other refrigerants type used in conventional air conditioning system. Therefore, conventional air-conditioning system is not practical to use nowadays even it is still able to fulfill comfort requirements for human because this system are energy intensive and not environmentally friendly. Conventional air-conditioning system divided into two types of system that is Vapor Compression Refrigeration System, VCRS and Vapor Absorption Refrigeration System, VARS (HVAC and Refrigeration System, Bureau of Energy Efficiency).