UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INLET AND OUTLET CONFIGURATIONS EFFECT ON THERMAL COMFORT

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Mechanical Engineering Technology of HVAC & R) (Hons.)

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921027-01-6536

FACULTY OF ENGINEERING TECHNOLOGY

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **INLET AND OUTLET CONFIGURATIONS EFFECT ON THERMAL COMFORT**

SESI PENGAJIAN: **2014/15 Semester 1**

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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 Engineering Technology (Mechanical Engineering Technology of HVAC) (Hons.). The member of the supervisory is as follow:

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(Dr Ahmed Salem Saeed Bin Ghooth)

ABSTRAK

Salur masuk udara dan konfigurasi outlet dilakukan dengan membuka atau menutup pengudaraan alur keluar yang berhampiran siling atau lantai dan menyediakan 100% udara segar untuk pengudaraan. Salur masuk udara dan outler memberikan effecet yang besar ke atas keselesaan terma. Walau bagaimanapun, ia adalah satu kaedah untuk mencapai pengudaraan yang baik 100% udara segar. Sistem penyaman udara konvensional ternyata telah menunjukkan beberapa beberapa batasan dari segi kos, penjimatan tenaga, perlindungan alam sekitar, perubahan iklim, piawaian industri dan perkhidmatan. Objektif utama projek ini adalah untuk mengkaji kemungkinan menggunakan HRC untuk memberikan 100% udara segar dan untuk menyiasat suhu bilik dan halaju udara dengan mengubah konfigurasi salur masuk udara dan keluar. Objektif itu boleh dicapai dengan membina dan ujikaji. Parameter yang paling penting dalam projek ini adalah suhu bilik kajian dan halaju udara oleh salur masuk udara dan outlet konfigurasi. Oleh itu, pengudaraan anjakan di peringkat kedua akan diterima dengan 0.1m / s sehingga 0.16m / s. Hasilnya adalah mendapatkan dengan uji kaji dengan mengukur suhu dan halaju yang berbeza-beza apabila salur masuk udara dan keluar. Kesimpulannya, kemungkinan menggunakan HRC di Malaysia adalah mungkin. Hasil kajian menunjukkan suhu bilik yang dicapai sekitar 24 ° C hingga 26 ° C dengan menyediakan 100% udara segar. Jika tidak, suhu bilik itu disiasat dengan mengkaji untuk mengubah konfigurasi dengan kesan suhu siling sejuk yang terjejas oleh air penyejuk. Keputusan yang diperolehi bahawa suhu bilik adalah sekitar 24 ° C hingga 26 ° C dengan halaju sekitar 0.10m / s kepada 0.16m / s. Keadaan keselesaan dicapai bagi kes pengudaraan anjakan di peringkat kedua panel siling sejuk.

ABSTRACT

Air inlet and outlet configurations is done by opening or closing the oulet ventilation that near the ceiling or floor and providing 100% fresh air for ventilation. Air inlet and outler give significant effecet on thermal comfort. However, it is a method for achieving good ventilation of 100% fresh air. Conventional air conditioning systems evidently have shown a few several limitations in terms of their cost, energy conservation, environmental protection, climate change, industry standards and service. The main objectives of this project are to study the possibility of using HRC to provide 100% fresh air and to investigate the room temperature and air velocity by varying the configurations of air inlet and outlet. The objectives can be achieve by fabricate and experimental work. The most important parameter in this project are study room temperature and air velocity by air inlet and outlet configurations. Therefore, the displacement ventilation at second level will be acceptable with 0.1m/s until 0.16m/s. The result is obtaining by experimentally by measuring the temperature and velocity when varying air inlet and outlet. As a conclusion, the possibility of using HRC in Malaysia is possible. The results indicated that the room temperature was achieved around 24°C to 26°C by providing 100% fresh air. Otherwise, the room temperature was investigated by studying to vary configurations with the effect of chilled ceiling temperature which was affected by chiller water. The result obtained that room temperature is around 24°C to 26°C with the velocity around 0.10m/s to 0.16m/s. This comfort condition is achieved for the displacement ventilation case at second level of chilled ceiling panel.

DEDICATION

I dedicate my disquisition work to my family and many friends. Firstly, I would like dedicate to my beloved parents, Abdul Halim Lim Bin Abdullah and Saadiah Binti Mahat, who have supported me all the way since the beginning of this thesis. I also would like to thank you to my entire friends that help me in completing this thesis. Especially my teammates in preparing prototype and conducting experiments, Muhammad Anuar bin Che Ismail and Mohamad Zulfiqkar Bin Hamlee, who collaborate with me on doing this project. I also dedicate a special thanks to Azrinshah Bin Abu Bakar for being supportive and helping me in completing this report. All of you have been my best cheerleaders.

ACKNOWLEDGEMENT

I wish to thank my faculty members who were more than generous with their expertise and precious time. A special thanks to Dr Ahmed Salem Saeed Bin Gooth, my supervisor for his countless hours of reflecting, reading, encouraging, teaching, and most of all patience throughout the entire process. Thank you to my bachelor degree project group mates, Muhammad Anuar Bin Che Ismail and Mohamad Zulfiqkar Bin Hamlee for completing the researches together. Special thanks go to staff from Laboratory of Faculty Technology Engineering Mechanical, Mr Khairul Fitri Bin Zainal for their cooperation and allowing us to use equipments from Air Distribution Laboratory. Finally, I would like to thank the academic advisor, Mr Omar Bin Asaroon that assisted me with this research. Their helping and teaching help me so much in completing this research.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

°C	-	Degree Celsius (temperature unit)
m/s	-	Meter per second (velocity unit)
m^3/s	-	Meter cube per second (air flow rate unit)
kg/L	-	Kilogram per Litre (concentration unit)
ACR	-	Air Conditioning/ Refrigeration
ASHRAE	-	American Society of Heating Refrigeration and Air Conditioning Engineers
DOAS	-	Dedicated Outdoor Air System
HRC	-	Hydronic Radiant Cooling
HVAC	-	Heating Ventilation and Air Conditioning
ICOP	-	Industry Code of Practice
MRT	-	Mean Radiant Temperature
TABS	-	Thermally Activated Building System

CHAPTER 1
INTRODUCTION

In chapter 1 introduction contains some subtopics which are the project background, problem statement, objectives, scope and organization of the thesis.

1.1 Project Background

Air conditioning is the process of treating air to meet the requirements of conditioned space by control simultaneously its temperature, humidity, cleanliness, and distribution. Thus air conditioning can also be described as the process of control the properties of air to more favourable or comfort condition. Typically, the purposes of air conditioning are to achieve comfort or improve comfort of surrounding. In the design of comfort air conditioning and ventilation systems, a few sources must be controlled such as odours arising from occupants, cooking, and heat from occupants. This will be accomplished by introducing fresh air or purified recirculated air in sufficient quantities to reduce these problems. It also can refer to any appearance of technology, heating, cooling, dehumidification, cleaning, ventilation or air movement that can modify the air condition. As described by the American Society of Heating,

Refrigerating, and Air Conditioning Engineers (ASHRAE), an air conditioning system maintain desired environmental conditions within a space and are categorized by how they control cooling in the conditioned space or area. Nowadays air conditioning becomes very important in our daily life because it gives us to reach with thermal comfort by giving desired low temperature. For example, it will reduce impact on our capability to perform and complete the work tasks, help to reduce dehydration as we lessen the likelihood of excessive sweating and automatically will help renew and improve air quality. Based on American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 55 (1992) defines that thermal comfort is the condition of mind that expresses satisfaction with the thermal environment of surrounding. It is needed for the room which can make the occupant feels too hot, too cold, or just fine. Although air conditioning is very convenient system, some limitations associated with, such as high energy consumption, interferences from light, window, door, appliances, furniture, dry bulb air and other cooling load. Bulb air temperature and mean radiant temperatures (MRT) are two variables that the design engineer could control on an individual room level but in most design situation, only the air temperature is considered rather than MRT.

Conventional air conditioning is energy intensive especially in hot humid climates due to consuming extra energy. This also shows the conventional air-conditioning systems uneconomical and energy intensive. However, the conventional air conditioning systems evidently have shown a few several limitations in terms of their cost, energy conservation, environmental protection, climate change, industry

standards and service due to, they are still rely on fossil fuel. Unlike conventional air-conditioning systems that rely on vapor compression, a typical hydronic radiant cooling (HRC) system will be considered as an alternative system in term of chilled ceiling system. HRC system provides acceptable cooling by combination of chilled ceiling and dehumidification system that required special attention especially relative humidity. The percentage of heat can be removed from the room through radiant cooling by determining the radiant panel surface temperature. Based on recent study by Zhang and Niu, they investigated on emerging air conditioning technology and proposed to replace conventional air conditioning called "Hydronic Radiant Cooling". Moreover, using this type of systems can also help room or building owners get credit points in green building rating and certification, such as using the LEED (Leadership in Energy and Environmental Design) system. When the chilled ceiling system is applied, energy consumption automatically can be saved or reduced.

Air conditioning in Malaysia is required chilled which due to hot and humid climate. Cooling provided by air conditioning system is heat removal by lowering the temperature and humidity of the surrounding air. Then, cooling by chilled ceiling panels would be used for product preservation and providing thermal comfort. Chilled ceiling system is a water-based cooling system that uses ceiling-based radiant cooling panels coupled with chilled water pipes or coils. Chilled ceiling systems have been introduced in Europe on the middle of 1980s. Now they are becoming popular in other countries. This system provides better thermal comfort as compared with conventional HVAC systems. The weakness of existing Heating, Ventilation and Air

Conditioning (HVAC) system can be resolved by using chilled ceiling systems which have highly potential to resolve it. In this project, I value more focus on vary the ventilation configuration of air inlet and air outlet; the velocity of air and room temperature. The chilled ceiling system can handle large sensible cooling load with relatively low sound level and quiet indoor environment easily. Theory predicts that cool ceiling would give better room convection patterns during the summer season. This shows that radiant ceiling is the most suitable preferred to install in Malaysia as Malaysia required cooling seasons only and not heating seasons in order to achieve thermal comfort.

There are six primary variables affect thermal comfort; activity level, clothing insulation value, air velocity, humidity, air temperature, and mean radiant temperature. So in this project, I will more focus on evaluating two parameters only. The parameters that need to be considered on this project are the room temperature and velocity of air by varying the configuration of air inlet and outlet. The basic design parameter is the quantity of air in the system need to deliver and there is direct relationship between the quantity of air, air velocity, and size of duct. The low air movement in chilled ceiling systems may help to enhance the thermal comfort and eventually will avoid excessive velocity or less velocity which can be obtained by prevention from stagnant air when natural convection is not adequate to generate the minimum air movement. Based on previous research on thermal comfort under radiant cooling ceiling it found that small air movement, especially including velocity change, had high tendency on improving the comfortable sensation. The relative humidity would be constant in this project. Therefore the humidity effects on

the heating or cooling system, and commonly referred to as a thermal distribution system for the entire building which may not be controlled at the room level. Usually, the air velocity is maintained at a level that avoids a draft and also provides the necessary fresh air for the occupants. Therefore, experimental work is carried out to measure the appropriate condition for Malaysian climate.

1.2 Problem statement

The main problem statement of this project is due to conventional air conditioning system is energy intensive, especially when fresh air provided, supplying 100% fresh air is a major challenge will be considered with energy reduction. Therefore introducing air conditioning (chilled ceiling panel) as an alternative to system conventional that relies on vapor compression system is essential. The project is focusing on the ventilation configuration of air inlet and outlet. The most important outlet are temperature with air velocity effects on thermal comfort.

1.3 Objectives

The main objectives of this project are

i. To study the possibility of using Hydronic Radiant Cooling (HRC) to provide 100% fresh air.

ii. To investigate the room temperature and air velocity by varying the configuration of air inlet and outlet.

1.4 Scope of Project

In this project, the areas of consideration are entire of the environmental chamber by varying the configuration of air inlet and outlet and chilled ceiling temperature. The air velocity and room temperature are recorded for the data required. On the other hand, the chilled water is constant and the position of chilled ceiling is varied in this project meanwhile the copper tube is covered with Aluminium. Otherwise humidity also is constant by reaching the comfort humidity level for Malaysia via using silica gel. This project conduct based on chilled ceiling panel.

1.5 Organization of the Thesis

This subtitle is a fundamental for the project. Strategy and acts as guidelines for project research completion. Generally, the thesis consists of five chapters. Chapter 1 is the introduction about the study. Chapter 2 presents the review of literature which describes previous methods and findings done by other people which are related to

the study. Chapter 3 is the methodology which explains the approaches and methods used in performing the project objectives. Chapter 4 reports the outcomes or results with discussion from the experimental work and chapter 5 consists of conclusion and recommendation for future work.

CHAPTER 2
LITERATURE REVIEW

In this chapter 2, I present the most important published works for the literature review; that relevant to current study, such as conventional air conditioning system, hydronic radiant cooling (HRC), thermal comfort, air configurations and summary.

2.1 Conventional air conditioning system

On these subtopics, I survey about conventional air conditioning system, chilled ceiling and mini chiller. Green and Perry (2008) claim that an air conditioning can be defined as the process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution to meet the requirements for the conditioned space. Therefore, air conditioning system is the system that will provide air to the conditioned space as to reach thermal comfort. They also states that based on American Society of Heating, Refrigeration, and Air conditioning Engineers (ASHRAE), an air conditioning systems can maintains the desired environmental conditions within a space and have been categorized by how they control cooling in the conditioned area.