UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PARAMETRIC STUDY ON HYDRONIC WALL COOLING SYSTEM USING DOMESTIC PIPE AS A RADIANT SYSTEM

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

by

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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 (Refrigeration and Air-Conditioning System) with Honours. The member of the supervisory is as follow:

……

(Dr. Mohamad Haidir bin Maslan)

ABSTRACT

Hydronic wall cooling system using domestic pipe purpose for applied green environment without using energy consumption as reduce or eliminate implementation any mechanism that involved for cooling method in residential house such HVAC system or other methods. By assigned heat transfer as the circular system around human to adapt in the research, simulation play a big role in this research to investigate the state and designed three model through simulation using ABAQUS CAE which are the conventional wall, wall with one sided cooling tube and wall with double sided cooling tube. The data properties for the model such brick, plaster, cement and copper material in the model are taken over from journal related with research and load from the solar radiation captivating from the Kuantan, Malaysia on December because the correlation source solar in this countries almost similar data for each state. As indicated each model as heat transfer phenomenon the data taken of temperature parameter in the model divide by two results perform from outside to inside in the wall and uniformity on the surface after wall. For each model were compare and explain the phenomenon during the simulation progress. It is shows the decreasing from double sided cooling tube model implement onto the wall resulting 27 ^{o}C equate from conventional wall model unique high temperature at 60 ^{o}C indicate conduction concept in the wall without applied domestic pipe or cooling tube before used in the model ideal. Water medium inside the cooling tube main areas to inconstant the temperature of the heat inside the wall by extract it through process convection accomplish effective cooling method further, thermal conductivity each material in the model affect the result temperature.

ABSTRAK

Sistem penyejukan dinding hidronik menggunakan paip domestik bertujuan untuk penggunaan persekitaran hijau tanpa menggunakan penggunaan tenaga untuk mengurangkan atau menghapuskan penggunaan mekanisme yang melibatkan kaedah penyejukan di rumah kediaman seperti sistem HVAC atau kaedah lain. Dengan pemindahan haba yang dilaksanakan sebagai sistem pekeliling dikalangan manusia untuk menyesuaikan diri dalam kajian, simulasi memainkan peranan yang besar dalam kajian ini untuk menyiasat keadaan dan merancang tiga model melalui simulasi menggunakan ABAQUS CAE iaitu dinding konvensional, dinding dengan tiub pendinginan satu sisi dan dinding dengan tiub penyejukan dua sisi. Ciri-ciri data bagi model bata, plaster, simen dan bahan tembaga dalam model diambil daripada jurnal yang berkaitan dengan kajian dan beban dari sinaran radiasi yang dari Kuantan, Malaysia pada bulan Disember kerana sumber korelasi solar di negara ini hampir menyamai data untuk setiap negeri. Seperti yang diterangkan setiap model merupakan fenomena perpindahan haba, data yang diambil dari parameter suhu ke dalam model diolah dengan dua graf yang dikenakan dari luar ke dalam dinding dan keseragaman pada permukaan selepas dinding. Bagi setiap model perbandingan dan penerangan setiap fenomena semasa proses simulasi. Ini menunjukkan penurunan dari model tiub penyejukan dua sisi yang ditanam ke dinding yang menghasilkan suhu 27 ^{o}C banding model dinding konvensional yang asas pada suhu 60 ^{o}C konsep pengaliran tanpa menggunakan paip domestik atau tiub penyejuk sebelum digunakan dalam model yang ideal. Medium air dalam tiub penyejukan untuk pemalar suhu haba dalam dinding dengan penyulingan melalui proses perolakan capai kaedah penyejukan yang berkesan lagi, kekonduksian terma setiap bahan dalam model dinding turut mempengaruhi keputusan suhu.

DEDICATION

To my beloved parents, I acknowledge my sincere obligation and appreciation to them for their love, vision and sacrifice throughout my life. I am humble my thankful for their sacrifice, tolerance and considerate that were inevitable to make this effort thinkable. Their sacrifice had inspired me from the day I learned how to read, write, and think until what I have become now. I disable to bargain the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to reach my dreams. Lastly, I would like to lead my gratitude to any person that contributes to my final year project either it is directly or indirectly. I would like to acknowledge their comments and suggestions, which are crucial for the successful completion of this research.

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CHAPTER 1
INTRODUCTION

This chapter is intended to provide background information of research conducted. It covers the background of research, problem statement, research objectives, scope of the research and structure of report.

1.0 Research Background

Heat energy one of the matter human need to control either removed or using as benefits to human themselves. This is can prove by system that human developing solar panel system source from the sun through solar radiation direct to the earth and human see the wasting heat energy can be used as convert power consumption and generate light on the road. People can see the development for this century using heat energy in order reuse it as good advantages tend to better environments humankind.

Even tough, in commercial building and residential house heat energy is the most matter need to control mostly due to the thermal comfort for each people that occupy in the space zone require. Each of the person have their own satisfaction of thermal comfort for the place that human inhabit. Heat energy from the sun transfer form to radiation and reach to the space surrounding outside air modes convection either been forced by moving air proportional forced convection can be transfer using natural convection at some level. Through this heat transfer when reached to the house, convection take place due to the boundary layer material passed through and once again turn to convection transfer in the inside of the house in the space surroundings. From

this observation, the heat energy cannot destroy even human cannot accept level heat energy that discomfort daily life all the time.

Based on this condition, student research the previous finding the ways human control the heat energy using Heating, Ventilating and Air Conditioning (HVAC) system to remove and reduce the heat that trapped in the space house. This system been introduced 100 years ago as a development during that time. HVAC application is a treatment of air circulation as required by occupants used for human comfort of for process control. The air conditioning system commonly used in Malaysia because only had two season which is rainy and hot weather. Comparison between commercial building and residential house air conditioning system used various categories type of system as required for space and zone needed. In commercial building, usually central system (Hydronic) and for residential house general used individual such split unit air conditioners. From this current, air conditioning system is a better controlled heat energy compare to other ways reduce the heat efficiency in surrounding.

As a result, the air conditioning system tends to use mechanical system that require a heavy power that lead to the energy consumption. For development to reduce this matter, engineers invent the better system with less energy consumption which is hydronic radiant cooling HVAC system. Hydronic radiant for cooling system is by water based and electrical system, but electrical system mainly provides for heating purpose only. This system can save large amount of electrical consumption because not using compressor due to high energy usage and excessive cooling that does not meet the thermal comfort requirement also vapour compression cycle system (VCCS) contains chemicals that can damage the ozone layer and risk of global warming. Nevertheless, this research invents further less energy consumption compare both system.

As to achieve target, hydronic wall cooling system using domestic pipe in the house is a method use it nature properties to remove the heat. By using nature characteristics, the system is working by itself. The energy drives the system is a very

low and at some point, it does not require an energy consumption. The hydronic wall cooling system is the new kind approach to green technologies.

Hydronic wall cooling system using domestic pipe is a technique of using water inside the pipe characteristic as a medium to extract heat from the wall to decrease the temperature. It uses a convection as a heat transfer mode. The convection mode heat transfer is a process that combine the conduction and flowing fluid. When it mentions wall, as a housing cooling, conduction take place during heat energy through the boundary layer of the wall. In general, this system gain impact to society on convenience system with power saving instead no energy consumption require in this research.

1.1 Problem Statement

Energy consumption for the convectional air conditioning system and radiant heating and cooling system still used to generate the operation for thermal comfort occupants. This is the important criteria to be defining to commercialize a certain system. When describing the cooling method, the most influence creation is the air conditioning as we might know the most contribute for energy consumption. In addition, using too much energy will harm environment. With no mechanical part added into hydronic cooling system, it does have problem with noise level as the main issue. Water flowing through domestic pipe can occur condensation if cool water temperature and occur negative feedback if hot water temperature flowing through the piping. The water temperature was not constant due to variable climate. This is challenge in this research in how analysis on hydronic wall cooling system to overcome energy consumption.

1.2 Objectives

The objective of this project study on parametric hydronic wall cooling system using domestic pipe. Aside from that:

Main objective is stated as follow:

1. To analysis using simulation of heat transfer effect through the hydronic wall cooling system using domestic pipe.

   To sub-objectives are stated as follow:

a) To design domestic pipe on the wall as a cooling system with hydronic medium using simulation.
b) To determine the effectiveness of hydronic wall cooling system using domestic pipe.

1.3 Scope of Research

This study was limited by following:

1. The main source of the heat is the solar radiation of Kuantan, Malaysia.
2. Wall material, water as medium in the domestic pipe, domestic pipe (copper) for each thermal conductivity have been assume from other researcher for the simulation.
3. The water temperature for the domestic pipe constant from general temperature in the hydronic pipe system housing from the forecast Kuala Lumpur perpendicular with simulation analysis heat transfer.
4. Area for the wall estimate from the actual standard housing in Malaysia.
5. The design for the domestic pipe on the wall added single sided and double sided which are on the exterior wall and interior of the wall.
6. The data gathering will been implement in the Abaqus software as a simulation.

1.4 Structure of Report

Following the Introduction (Chapter 1), this report is divided into the following chapters:

Chapter 2 Literature Review

This chapter present a literature review on previous relevant works, discussing the state of sculpture in the field according to scope of this research. It consists of heat transfer, house cooling system, radiant cooling system and wall cooling system

Chapter 3 Methodology

This chapter present a methodology for this research using analysis simulation process. It consists sketch of planning, explanation in experiment and simulation, equipment related and simulation to analysis.

Chapter 4 Results and Discussion

This chapter elaborates the three models from simulation in ABAQUS CAE towards hydronic wall cooling system using domestic pipe from the conventional wall to one-sided and double-sided cooling tube. The figure of simulation and curve of the temperature will be discussed in this chapter to achieve the main objective under research areas. Finally, double-sided cooling tube predicted as the greater efficiency proven by simulation.

Chapter 5 Conclusion and Recommendation

This chapter concludes the current state of the analysis simulation, gives a summary of key results and provides details of the planned future work.

CHAPTER 2

LITERATURE REVIEW

While the first chapter clarified the background of the study, this chapter proceeds with a fully-referenced review from the relevant literature. It covers to Heat Transfer, Conduction, Convection, Radiation, Housing Cooling System, Hydronic Cooling System, Tropical Climate and Thermal Conductivity.

Wall hydronic system is a common alternative way of cooling or heating method for commercial and residential building nowadays. It commonly used in four season country that provided by for reduce the energy consumption beside control the heat outside through the wall.

2.0 Heat Transmission

Heat transmission or heat transfer is the form energy that cannot be destroy but can be transferred from one medium to another because of temperature different. In other definition, heat transfer is a transfusion of thermal energy between physical systems. It flows from regions of higher temperature to regions of lower temperature and customary to refer to different types of heat transfer mechanisms as modes (Rohsenow, Hartnett, & Cho, 1998). Amount of heat transfer as a system undergoes a process from one equilibrium state to another concerned by thermodynamics. Determination of the rates of such energy transfers as well as variation of temperature dealing with heat transfer. According to Binay K. Dutta, the principles of heat transfer

enable us to calculate the rate of transport of thermal energy meanwhile classical thermodynamic, on the other hand, deals with processes and systems at equilibrium. In properties heat transfer, the transferred stop when two mediums reach the same temperature. Heat can be transferred in three different modes which are conduction, convection and radiation. But the first two modes appear to be dominant in many practical fields meanwhile radiation is the most important mode of heat transfer at elevated temperature (Binay K. Dutta, 2006). As example in daily life of heat transfer application areas are the human body, Heating Ventilation Air Conditioning system, electronic equipment, power plants and so on. Figure 2.1 shows example on how to understand differentiate heat transfer modes between modes. This figure explains on characteristic the modes transfer of heat as a imagination how the modes flow from one to another.

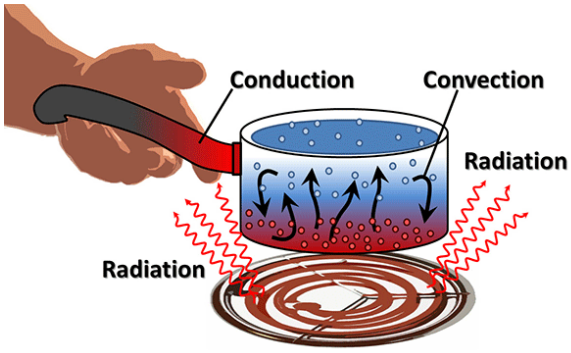

Figure 2.1 Source: Difference Between Conduction, Convection, and Radiation

Radiation modes of heat transfer begin transfer through convection either natural or forced and heat will have passed through in space surrounding normally will through conduction process on material that had medium reach variation of temperature until it will stop when reach same temperature each medium. In this wall cooling system using domestic piping water, student will study heat transfer between fluids separated by a plane wall. That will cover on overall heat transfer coefficient in this section. Heat transfer from one fluid to another separated by an intervening solid wall is of great practical importance (Binay K. Dutta, 2006). Figure 2.2 shows illustration of wall in this research before applying the cooling system using domestic piping water and parameter and labelling temperature, thickness, heat transfer coefficient and

thermal conductivity in the material wall. The line decrease represents how the heat reduce through boundary of wall.

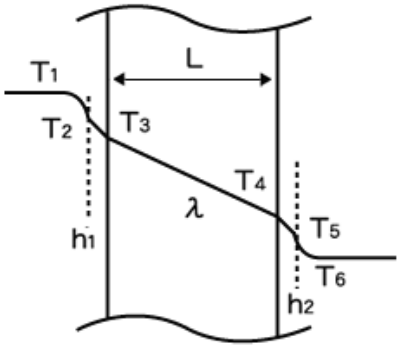

Figure 2.2 Source: Overall Heat Transfer Coefficient

2.1 Conduction

Conduction modes of heat transfer for wall cooling system that using domestic piping water as medium between plaster and brick will been studying to determine how much heat absorb from material of the plane wall within pipe water. Conduction is the transfer of energy from the more energetic particles of a substance to the adjacent less energetic ones because of interactions between the particles. The conduction process takes place at the molecular level and involves the transfer of energy from the more energetic molecules to those with a lower energy level (Rohsenow et al., 1998). In addition of phase gases, liquids and solid, conduction present too due to their properties. In gases and liquids, during their random motion conduction approach due to the collisions and diffusion of the molecules meanwhile in solids it is due to the combination of vibrations of the molecules in a lattice and the energy transport by free electron.

In liquid, the molecules are more closely spaced than in gases, but the molecular energy exchange process is qualitatively like that in gases. In solids that are

nonconductors of electricity (di- electrics), heat is conducted by lattice waves caused by atomic motion. In solids that are good conductors of electricity, this lattice vibration mechanism is only a small contribution to the energy transfer process, the principal contribution being that due to the motion of free electrons, which move in a comparable way to molecules in a gas (Rohsenow et al., 1998).

Temperature difference across the layer and heat transfer area was direct proportional through a plane layer by rate of heat conduction but inversely proportional to the thickness of the layer. Conduction modes as show in Figure 2.3 explains conduction took place during the heat transfer begin.

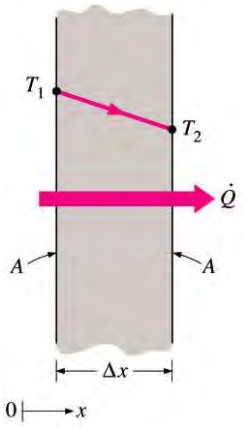

Figure 2.3: Heat conduction through a large plane wall of thickness Δx and area A.

$$Rate\ of\ heat\ conduction\ \propto \frac{(Area)(Temperature\ difference)}{Thickness}$$

$$\dot{Q}_{\text{cond}} = kA\frac{T_1 - T_2}{\Delta x} = -kA\frac{\Delta T}{\Delta x} \quad \text{(W)} \qquad (1)$$

Q' conduction = heat amount through conduction modes

k = thermal conductivity

T_1-T_2 = temperature difference

Δx = thickness of the plane wall

Temperature gradient becomes negative when temperature begin lower with higher the thickness when heat is conducted in the direction of lowering the temperature. Equation above that show negative sign make sure heat transfer in the positive x direction is a positive quantity. In addition, domestic piping system on the wall inside and outside will been determining to get heat amount when conduction happen using simulation.

2.2 Convection

Convection take place outside and inside of modes heat transfer before through the plane wall or there was a gap between the plane wall material and should not ignore to find amount of heat housing plane wall. Convection, sometimes identified as a separate mode of heat transfer, relates to the transfer of heat from a bounding surface to a fluid in motion, or to the heat transfer across a flow plane within the interior of the flowing fluid (Rohsenow et al., 1998). Convection modes of heat transfer become greater when the fluid motion dissipates faster. When the bulk fluid motion absence, heat transfer was pure conduction between solid surface and the adjacent fluid. Equation below is for to find heat using convection modes and knowns as the "Newton's law of cooling".

$$\dot{Q}_{conv} = hA(T_S - T_O) \qquad (2)$$

$\dot{Q}_{conv}$ = heat amount through convection

h = heat transfer coefficient

Ts = surface temperature

To = bulk fluid temperature