I hereby declare that I have read this thesis and my opinion this thesis is sufficient in term of scope and quality for the award of the bachelor of Mechanical Engineering (Thermal-Fluid)

Signature : ………………………………

Name of Supervisor : Mrs Ainil Jesita Bte Jalaluddin

Date : 27 March 2008

I hereby the author, declare this report entitle "**EVAPORATIVE ROOF COOLING SYSTEM USING WATER FOR HOUSEHOLD APPLICATION** is my own except for quotations and summaries which have been duly acknowledgement"

Signature	: ………………………………
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Firstly, I would like to thanks to Allah S.W.T for his goodness and grace that sustained me to completed Projek Sarjana Muda 1.

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ABSTRACT

Evaporative roof cooling is one of the methods for cooling house. In this project, many aspects are considered to make this evaporative roof cooling system. The aspects were considered for this project is the hot climates in Malaysia, the roof that can load heat and make the house are hot and higher uses electricity. Therefore that the evaporative cooling roof system will be applied. The factor will be take in this system is scale of house, the types of the roof, system design, the operation of the system, device of the system to get the expected results. The situation of the water is also important in part the velocity and the flow of the water to make the project success. The result of this project is the decreases of the roof is about 21% depends to the environment temperature, air velocity, and the relative humidity.

ABSTRAK

Penyejukan bumbung melalui kaedah penyejatan adalah salah satu cara untuk menyejukkan rumah. Di dalam pengajian ilmiah untuk Projek Sarjana Muda 1 ini, banyak aspek telah diambil kira untuk mengkaji dan menjalankan sistem penyejukan bumbung melalui kaedah penyejatan air ini. Antara aspek yang diambil kira adalah cuaca di Malaysia yang boleh dikategorikan panas, bumbung yang banyak menyerap haba matahari yang menyebabkan rumah panas serta penggunaan kadar elektrik yang tinggi. Oleh itu masalah-masalah kepanasan rumah boleh diselesaikan melalui cara penyejukan bumbung melalui kaedah penyejatan air. Antara faktor yang diambil kira untuk menjalankan projek ini adalah, skala rumah yang digunakan, jenis bumbung untuk kajian projek ini, konsep sistem ini, reka bentuk sistem dan juga alatan eksperimen yang akan digunakan untuk mendapat keadaan rumah yang selesa untuk penghuni rumah. Kadar aliran air di atas bumbung dan cara pengaliran air juga adalah salah satu aspek penting yang memainkan peranan untuk penyelesaian masalah projek ini. Keputusan yang telah dicapai pada projek ini adalah pengurangan suhu bumbung lebih kurang 21% bergantung pada suhu persekitaran, halaju udara, dan kelembapan nisbi.

CHAPTER 1

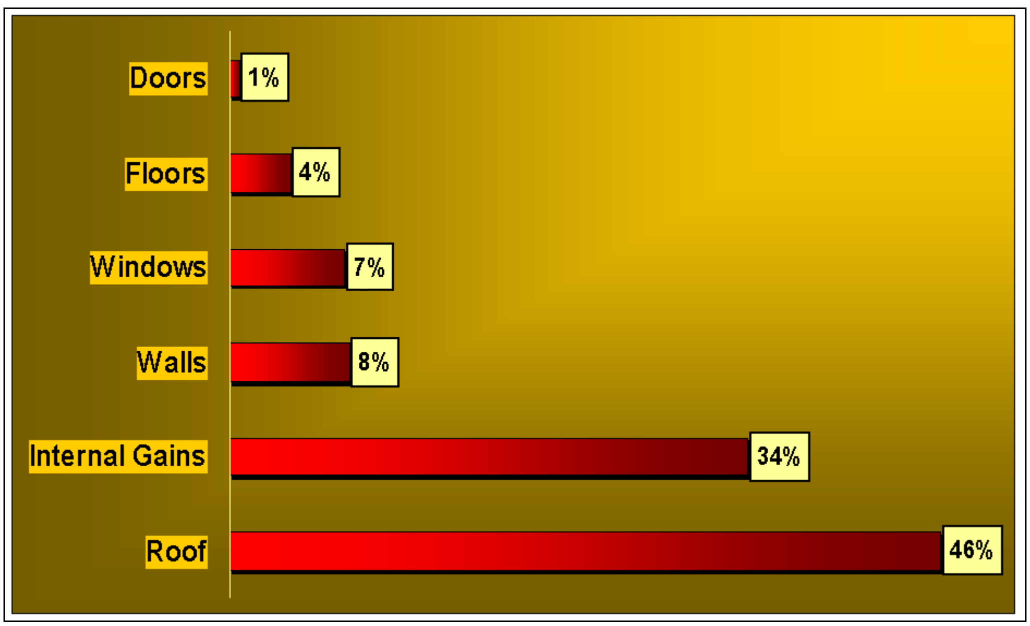
INTRODUCTION

1.1 House Heat Factor

There are three modes of heat transfer in the house. First is conduction, second is convection and third is radiation. Before that, heat is transfer from high temperature object to a lower temperature object. Conduction is the transfer of heat through a solid object, for example when the hot environment outside of the house. The outer part of the walls and the windows are be hotter than the inside part. The second mode is convection, where heat is transferred through liquid or gases. For example cold air enters a home. It mixes with warm air where heat energy is transferred to the cooler air and the overall temperature of the room is lowered. Radiation is occurs when heat transfer is in the form of electromagnetic energy, through space. For example when sunlight enters a room through a window where heat energy is transferred to the room.

1.2 Problem Statement

Heat is transferred to a house via doors, floor, windows, walls, roof etc. The percentage heat transferred through these different components of house is illustrated in figure 1 (source: www.ecoology.com)



ASHRAE Model

Figure1.1: Chart of percentage heat transferred at different components of house

From the graph in figure 1, the roof transfers the highest heat load followed by internal gains such as heat from lighting and computers in house. The combined heat transfer through the walls, doors, windows, and floors is only 20%.

Good house design is very important to prevent heat entering the house. The aspects that must consider are heat gain through roofs, walls, indoor space and floor. If we do not take into account factor, house temperature may reach high and uncomfortable values. For the wall, one of the aspects is the thickness of the wall, if the thickness of the wall is high; the heat allowed into the wall is low compared to wall of lower thickness. Another aspect is the color; colors of the walls must be light or white. If the dark colors are used, the wall will absorb more heat in through the house. For the floor, use tile are better because of smaller heat transfer through the house. If the owner uses a carpet, a slight increases in room temperature maybe observed compared to using tiles only. The amount of space in house also affects in house temperatures. The important aspect is the aspect is the space between the walls and the ceiling. If the space between wall and ceiling small, it is most likely to be hotter than a bigger space between wall and ceiling. (Henry Feriadi et al 2004).

The roof is one of the main contributors to heat gain in a house. Roof materials, structures, colors are different factors affecting heat transfer through a house roof. Another factor is the roof reflectivity. When the roof can reflect the sunlight, its can decrease the heat absorb. In terms of roof structure, the lighter colors are better like white because the heat absorbed is small compared with the darkness colors. Another factor is space between ceiling and roof. Larger space is better than small spaces.

Roof is one of the part in the house can loaded a large heat. Evaporative cooling roof will reduce roof's surface temperature 122-158 ºC when summer days. This amounts in an estimated 20-30% reduction of the buildings total heat load. In other words, the air conditioning lasts longer and works less, thus reducing the amount of energy required to cool the facility. This system will have estimated money payback about 2-3 years.

The temperature of a house is primarily dependent upon the temperature of the roof and walls. Roughly 50% of the heat load in the building is from the roof only. Therefore evaporative roof cooling has been studied for effective cooling. Different systems have been considered in the present study.

1.3 Objective

To design an evaporative roof cooling system using water for household application.

1.4 Scope

- Establish an important parameter in evaporative roof cooling system design.
- Conduct experiment by varying the chosen parameter to determine optimum configuration for best thermal performance.
- Test the final design based on experiment finding.

1.5 Expected Result

At the end of this project, this system of evaporative cooling roof can operated with the expected results.

CHAPTER 2

LITERATURE REVIEW

2.1 Cooling in House

There are many methods to reduce heat in a house where it is can be divide in two groups. First method is mechanicals such as air conditioning and exhaust fans. The second method is the passive cooling technique.

Below is the list about of different passive cooling technique for cooling a building (N.M Nahar et al. 2002).

a) Color control
b) thermal insulation over the roof
c) Roof pond/nocturnal cooling and heating
d) Evaporative cooling
e) Reflective
f) Air void thermal insulation over the roof (room in space)
g) Radiative cooling method
h) Convective cooling method

N.M Nahar et al. (2002) investigated different passive cooling techniques and found the evaporative cooling as best for conventional roof, but it is requires about 501/m² water per day. The pieces of white glazes tile stuck over the roof reflective techniques can be used to reduce heat load from the roof and hence cooling of the environment inside building. Another study in passive technique has been done by Hamida Ben cheikh et al. (2003). They investigated evaporative-reflective roof for hot dry climates and the analysis of the results shows the most significant factors affecting the cooling power of the passive cooling roof were the water volume, aluminum roof thickness and room air space width.

Ronnen Levinson et al. (2004) investigated cooler tile roofed building with near-infrared-reflective non-white coating. The results are the energy usage is reduced and the return of the money time is about 5-7 years in the warm climates of Fresno and Son Bernardino,

There are many other passive techniques to make the temperature in house constant and at a lower temperature. The passive technique can reduce cost of electricity and this system is environmental friendly. This technique are good for the long term and usually the payback is not too long.

Evaporative cooling roof was defined the best system for cooling house (N.M Nahar *et al* 2001). Although this techniques is very useful for cooling of building in arid areas where solar radiation and high wind speed are available. By this technique, indoor dry bulb temperature can be achieved near the outdoor wet bulb temperature.

2.2 Roof Evaporative Cooling

Evaporative cooling one of the processes are consider the cooling of the air or of thermal masses. It is the natural processes to remove heat from the air. Heat from the air can evaporate the water. The amounts of the heat absorbed to define the evaporated system depend on the amount of the water.

Evaporative cooling system can divided into two processes. This situation can be direct or indirect system depend to the contact the cooled air and the evaporated water. Evaporative system also can be passive or hybrid, based the energy required producing the evaporation.

In the direct situation, the incoming air will contact to the evaporated water and the water to increases the cooled air. For indirect situation, it let the water evaporated at the outside surfaces and the cooling effect to the inlet air like a heat exchanger. The passive evaporative cooling techniques is used of natural evaporation water via out roof surface can be cooled by passive technique like let the water flow at the surface of the roof to make the indoor space cool. The hybrids evaporative techniques is additional the passive technique above with the mechanicals device like pump to generate the water flows as well as the valve to control the flow of the water.

Passive direct technology is air humidification and cooling by evapotranspiration of plants and use to free water surface like pools and streams. Roof sprinkling and roof pond is the sample of the passive indirect evaporative cooling.

2.2.1 Roof Evaporative Cooling System

List of the system in this study

- Roof sprinkler
- Roof ponds
- Ponds Beneath the building
- Moving water film

2.2.1.1 Roof Sprinkler

This is popular system for evaporative cooling system. In this system, water will be spray at the top of the roof and than this water will evaporate. At the same time, this water will absorbs the large amount of heat.

Figure 2.1: Evaporative roof cooling using the sprinkle system (Source: http://autosftsystem.com)

2.2.1.2 Roof Ponds

Roof pond system is simpler than sprinkler system. The pond constructed above the plate roof and this pond must be shaded to avoid it heating during the days. The evaporating water cools the building by conduction across the roof. Both indoor air and radiant temperatures decrease without rising indoor humidity. Since it requires the conduction through the roof, this technology should only be applied on non insulated roofs. In order to prevent high heat losses in wintertime, roof ponds are only recommeded for hot climates without cold winters.

2.2.1.3 Ponds beneath the Building

Another variant of this physical method is to place ponds on the ground next to buildings, with a much larger depth of water. In this case it is possible to maintain the water temperature near or even below the average diurnal wet bulb temperature by fine spraying of the water over the insulation of the roof. The cold situation can be used. For example the tube is installed inside pond where warmer air of the building circulates during the day. The pond can be defined as a sink of the heat.

2.2.1.4 Moving Water Films

The moving water film is depending of the flow of the water. The increases of the velocity of the flow can make the quality of the evaporation process. The moving water films can be defined as a direct evaporative cooling. For this situation the flow of the water over the roof can make increasing indoor humidity depending on the decreased of the temperature of the roof.

2.3 Thermal Comfort

According to America Society of Heating, Refrigerating and air conditioning Engineer (ASHRAE), thermal comfort for human means the satisfaction with the surrounding environment. ASHRAE standard 55 mean thermal environmental conditions for human occupancy. Design Engineers of heating, air ventilation and air conditioning (HVAC) is target to achieve a thermal comfort for most occupants of buildings. Indoor air quality is not target to get the thermal comfort but one of the aspects for HVAC design engineers.

In 1970s, the studies about thermal comfort and the ranges of dry-bulb temperature, relative humidity, and activity level were completed. Research and development was doing by ASHRAE from this studies and refinement the ASHRAE Standard 55. This standard range was present at Kansas State University and many of the audience were satisfied with the range of the thermal comfort. Most Important of thermal comfort is called operative temperature. This is called for the average of the air dry-bulb temperature and the mean of the radiant temperature at the given place in the room. Description of this operative temperature is low air velocities and no drafts, little variant radiation in many way directions in the room, the humidity in the comfortable range. The air temperature at the 0.1m and above from floor should lowers than temperature of occupant’s head and the margin must not lower more than 2°C. The temperature surroundings must not change rapidly either cross with space or the time. Another aspect is the clothes and the activity of the occupants. The standard value of the thermal comfort is 25 +/- 2°C.

2.4 Determine of Thermal Comfort Temperature.

The major aim of comfort research is to find comfort temperature for an individual or group. However, 6 major variables determine how warm or cold a person feels.

2.4.1 Environmental factors

This is 4 factors to show the environment situation

-air temperature
-air speed
-humidity
-mean radiant temperature

2.4.2 Individual factors

-activity
-clothing insulation
-Possibly also individual differences, and recent thermal history.