UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION ON WASTE MATERIALS AS THERMAL INSULATION FOR BUILDING

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MASTER IN MECHANICAL ENGINEERING
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Faculty of Mechanical Engineering

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DECLARATION

I declare that this report entitled "Investigation on Waste Materials as Thermal Insulation for Building" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Ihab Munther Naji

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master in Mechanical Engineering (Energy Engineering).

Signature	:	……
Supervisor Name	:	DR. Mohd Zaid Bin Akop ……
Date	:	……. ……

DEDICATION

To the one who gave me birth, to the reason of my existence.

To the one who give a taste to this life.

To the one that the tired of life filled his shoulders every morning to let me grow up.

To whom that Wrinkles filled his face and bleached his hair.

To the reason of reaching this point, My Father, and Mother.

To those who make me laugh, my siblings.

To the candle that removed the darkness of my way

To the wedges, that gave me strength, my teachers.

To the souls that support me near every edge, that hearts, those umbrellas that kept me away from the rains of despair, my beloveds, and friends.

I dedicate the hours of my effort that manuscript on those papers of the past days.

ABSTRACT

Wall insulation is one of the most important things that can keep the surrounding temperature of the homes or any building suitable. It helps in maintaining the human comfort. The wall thermal insulation besides of keeping the area comfortable it may also help to achieve a reduction in consumption of energy while using heating or cooling systems of a house by saving energy and makes the surrounding area comfortable faster than usual. The aim of this research is to choose a potential material to be as a future thermal insulation. It focuses on waste materials such as coconut coir and cellulose. This research takes these two materials to test and analyses them using reconfigurable model house Marcraft GT-7500 and compare them with the results that have been gotten from common thermal insulations by making an experimental test for all these materials. Calculate the thermal effectiveness of each thermal material selected from the data that recorded. Various cases were conducted in reconfigurable model house to each of the materials that have been chosen. These cases are done by installing all material that selected sequentially in the cavities of a mini house and exposes different heat sources on them. Case one is using the ambient temperature as a heat source without any load. Case two is using an external heat source, while case three is done by using an internal heat source. All these three cases will help to give a much data to analyses and knowing the performance of materials when they are as a wall thermal insulation. At the end of the experiment, it shows that the coconut coir and the cellulose materials in a small gap comparing with the common thermal insulations and they can reliance on them in the future as thermal insulator for walls.

ABSTRAK

Penebat dinding adalah salah satu perkara yang penting bagi mengekalkan suhu persekitaran di dalam rumah atau mana-mana bangunan yang diingini. Ia membantu dalam mengekalkan keselesaan bagi manusia. Berfungsi sebagai penebat haba bagi dinding di samping memastikan keselesaan ruang, ia juga membantu untuk mencapai pengurangan penggunaan tenaga semasa menggunakan pemanas atau sistem penyejuk rumah dengan menjadikan kawasan persekitaran berkeadaan selesa lebih cepat daripada biasa. Tujuan kajian ini adalah untuk memilih bahan yang berpotensi untuk menjadi sebagai penebat haba di masa akan datang. Ia memberi tumpuan kepada bahan-bahan buangan seperti sabut kelapa dan selulosa. Kajian ini menggunakan kedua-dua bahan-bahan untuk diuji dan dianalisis menggunakan model rumah Marcraft GT-7500 dan membuat perbandingan dengan keputusan yang telah didapati dari eksperimen menggunakan bahan-bahan terpilih ini. Pelbagai kajian telah dijalankan di dalam model rumah jenis boleh dibentuk semula untuk setiap satu daripada bahan-bahan yang telah dipilih. Kajian-kajian ini dilakukan dengan memasang semua bahan yang dipilih secara berurutan dalam rongga sebuah rumah mini dan mendedahkan sumber haba yang berbeza pada mereka. Kes pertama menggunakan suhu ambien sebagai sumber haba tanpa sebarang beban haba lain. Dalam kes kedua menggunakan sumber haba luar, manakala kes ketiga dilakukan dengan menggunakan sumber haba dalaman. Semua ketiga-tiga kes akan membantu untuk memberi maklumat yang berkaitan untuk tujuan analisis dan mengetahui prestasi bahan apabila ia dijadikan sebagai penebat haba dinding. Pada akhir eksperimen, dapat dibuktikan bahawa sabut kelapa dan bahan-bahan selulosa dalam jurang yang kecil dibandingkan dengan penebatan haba biasa dan sesuai dijadikan sebagai penebat haba untuk dinding bagi masa akan datang.

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"Are those who know equal to those who do not know?".

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LIST OF ABBREVIATIONS

EPS	-	Expanded Polystyrene
EXP	-	Extruded Polystyrene
DIY	-	Do it yourself
MF	-	Melamine Foam
ASTM	-	American Society of Testing and Material
CCP	-	Coco Coir and Polypropylene
CB	-	Commercial Brand
CHB	-	Calibrated Hot Boxes
GHB	-	Guarded Hot Box

LIST OF SYMBOLS

$\dot{Q}_A$	-	Heat Flux
A	-	Area
ε	-	Emissivity
g	-	Gravity = 9.81 m/s
Gr	-	Grashof number
h	-	Heat transfer coefficient
H	-	Height
K	-	Thermal conductivity
L	-	Thickness
Nu	-	Nusselt number
Pr	-	Prandtl number
Q	-	Heat transfer rate
R	-	Resistance
Ra	-	Rayleigh number
$T_{ambient}$	-	Ambient temperature
Tf	-	Film temperature
Ti	-	Inside temperature
T_o	-	Outside temperature
w	-	Width
β	-	Expansion Coefficient
σ	-	The Stefan Boltzmann constant = 5.670367×10^{-8} (W m^{-2} K^{-4})

u	-	Dynamic viscosity
v	-	Kinematic viscosity
ρ	-	Density

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CHAPTER 1

INTRODUCTION

1.1 Background

Energy can be defined as the strength and vitality that required for the substance to do work (Cutler & Christopher, 2009). Energy can take multiple forms and changed among these forms. The change of energy can be from one form to another such as lighting, electrical energy, chemical, mechanical energy, sound, thermal energy, and the last energy is the nuclear (Ettie, 2011). Heat considered as thermal energy. It's the transfer of kinetic energy from one place to another by different interactions with the surroundings due to a spatial temperature difference. This process called 'heat transfer'. There are 3 modes of heat transfer process. These modes are conduction, convection, and radiation (Hassani et al., 2000) . Conduction first method of heat transfer through solids. It is the heat energy transfer process from different parts of the same body at different temperatures, from higher temperature to a low temperature. Or it occurs when two object at different temperatures one is cooler than the other and they are in contact with each other. Heat transfer through objects till they become at the same temperature (Jiji, 2000).

Convection is heat transfer occur to the fluid such as the air or liquid, when they heated by a hot surface. This transfer happens according to a mass motion of fluids. When the heated fluid moves away from the heat source, convection heat transfer will occurs carrying the thermal energy that got from the surface and transfers it to the cold fluid. The same working principle as conduction but convection is for fluids only (Bejan, 2013).

Radiation is the heat transfer that doesn't rely on any contact between the heating source and the object. Thermal radiation or it called infrared radiation is the way of transmitting the heat, it can work in space. In a radiation, there is no need for medium to transmit the heat and no need for a mass exchanged. It is unlike conduction and convection. It can be done by transmitted of thermal energy by infra-red radiation from the hottest object to another object that has less temperature (Liou, 2002). comfort to human

After knowing the energy, thermal energy, and methods of how thermal energy transfer to and from the space. The relation between human and the heat can be identified as thermal comfort. It is "that condition of mind which expresses satisfaction with the thermal environment when the body functions well". Human comfort is achieved when the surrounding circumstances are appropriate in terms of temperature, appropriate conditions avoid the person feel cold or too hot with a normal body temperature is 37°c to every human being. The body temperature of the human can be changed depending on the climates and it could be maintained in various ways. For sure it's different from one country to another. In most countries, it is uninhabited. Generally, Malaysian climate is hot. To achieve the thermal comfort to a human body, cold or moderate air must provide using air-conditioning devices or any other cooling equipment.

There is an important thing must take into consideration, it about the keep of good atmosphere and save the energy in the building. The increase in the cost of energy production this emphasizes to find an immediate solution and work to energy conservation even in countries has the oil producing.

In building sectors, there is an effective way to save the energy it is by using thermal insulation to keep the environments of the building steady.

Hot climates countries, energy conservation are particularly important for them because of the high price of the energy while using air conditioning devices. Isolators are one of the main used items to conserve energy and is considered one of the important materials during the construction, of its efficiency to reduce the energy used in buildings. In fact, without using insulations even some of energy efficient components won't perform as intended in a home. Keeping the home at a certain temperature is the benefit of using insulation. Keeping it hot in the winter and cold in summer seasons. Insulation can be considered as the most cost effective method for energy conservation and reducing the electricity bills. Insulation is not only used for saving energy, it is also used to reduce the noise and give more quality and comfort to buildings.

The capability of insulator material is measured by thermal conductivity (k). Thermal conductivity is the value that can determine the ability of the specified material to conduct the heat. Also, can be known as the flow of heat through the unit of area (Pryazhnikova et al., 2017). The SI unit of thermal conductivity is watts per meter kelvin (W/m.K.). There is an inverse relationship between the value of (k) to the capability of insulations. When the thermal conductivity is low that mean, the insulation has good quality. R-value indicates insulation capability.

Due to the high prices of thermal insulation exist in markets, this study will be concerned with waste materials that could be as alternative thermal insulators. Coconut coir and cellulose are taken as an example for this study. Coconuts are abundant in coastal areas of tropical countries. The coconut husk is available in large quantities as residue from coconut-fiber mattress production in many areas, which yields the coarse coir fiber. The husk consists of 30% fiber and 70% pith (Satta & Steve, 2011).

Cellulose board is a material that has a low-thermal conductivity can be used as buildings insulation to reduce the heat loss and gain, also, can reduce noise transmission (Pablo et al., 2016). Cellulose that particularly comes from recycled papers. This type of insulation called cellulose fiber. It is used to fill the cavities that previously prepared in walls and roof. This study takes a part to explain the differences among the thermal insulations. Also, many experiments are done on the coconuts coir and the cellulose fiber to approve their efficiency and performance and how they can help to conserve energy.

1.2 Problem Statement

Wall insulation plays an important role nowadays. It keeps our homes inside comfort in temperature. In summer keep the surrounding area acceptable as well as in winter. The fluctuations in climate make us find a solution to keep our bodies inside homes safe. The weather controls how and where we live, what we do, what we wear and what we drink. Due to the continuing changes of the weather state during the year and fluctuations that occur in temperatures and the different of climate from one place to another, that lead us to use different devices such as cooling and heating devices.

The purpose of these devices to make our surrounding area feel comfortable, at home or any other building. This technology is not for free and this lead to another problem for us, it requires an amount of money for buying these equipment and extra money for electricity bills while they are working.

Heating and cooling devices are not the only way to maintain the temperature inside, thermal insulation considers as a solution in maintaining human comfort. Insulations may also help to achieve the reduction in consumption of energy while using

heating cooling systems of a house by saving energy and makes the surrounding area comfortable faster.

Thermal insulations create a barrier around the house to achieve the thermal comfort. This barrier blocks the heat from entering the house on warm days, and in cold days reducing the amount of heat loss.

Choosing the right insulation is an important task to avoid unnecessary costs while chosen the wrong insulation. There are different types of thermal insulations. Each one of them has specific properties and different price depending on the use and the material. The aim of this research is to choose a potential material to be as a thermal insulation. It will focus on waste materials such as coconut coir and cellulose. Coconut coir available in abundance especially in Malaysia that will help to get them easily. Cellulose can be made and formatted from recycled papers as insulation.

1.3 Project Objectives

i. Choosing five materials as a wall thermal insulation for the experiment. They are divided into two groups, the common thermal insulation (polystyrene, fiberglass, and cotton) and waste materials (cellulose, and coconut coir).

ii. Identify their thermal properties by installing the materials selected in reconfigurable model house Marcraft GT-7500 and insert the data obtained in mathematical equations**.**

iii. Comparing the results of all five materials and find out the validity of using the waste materials (cellulose and coconut coir) as a wall thermal insulation for wall building.

1.4 Scope of Study

The scopes of this project are:

i. Test and analyze five materials as thermal insulations of building walls.

ii. Experiments will be conducted in reconfigurable model house Marcraft GT-7500.

iii. Evaluate the condition of installed insulation using the infra-red camera and thermocouples.

iv. The measured data are used to analyze the rate of heat loss from the mini model when installed each of the insulator.

1.5 Significance of This Study

Due to the growing of the evolution in the world, many of sectors impacted this development. The construction sector is one of them. Thermal insulation became one of the most important materials of construction. Various materials have found to be as a thermal insulator and their properties differ from each other. This study contributes of choosing a thermal insulation that have a high thermal effectiveness and regular price for using it in buildings. Many experiments are done on waste materials to identify their properties and find the best of them to be as alternative insulation. Various aspects and parameters are taken to be measured in order to determine the level and performance of waste materials.