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THE DESIGN AND DEVELOPMENT
OF WATER HEATER SYSTEM
USING SOLAR THERMAL RADIATION

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This report is submitted in accordance with requirement for the
Bachelor Degree of Mechanical Engineering
(Design & Innovation)

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This report is the result of the ever growing concern about our natural surroundings. It is time that engineers give back to mother earth. This report is hoped to be a spark that light the fire to further harness environmentally friendly and abundant energy to preserve the planet ultimately.

I dedicate this to my father for his unyielding support, my mother, my siblings and my brother, Harith.

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I declare that this final year project (1) report entitled “The Design and Development of Water Heater System Using Solar Thermal Radiation” is my own work except as cited in the reference.

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ABSTRACT

Solar water heaters are a common piece of technology nowadays. However it is still not as popular in Malaysia as it is at other developed countries. This is the design of a solar water heater using basic principles of thermodynamics which is thermal radiation, convection and conduction. This project is done by using proper methods of product design process such as indentifying product needs and Product Design Specifications (PDS). The project also incorporates elements of Thermodynamics. This design has specific goals where it is actually more into the solar collector efficiency and design to increase the heat taken to heat up water.

ABSTRAK

Pemanas air solar adalah teknologi yang sudah biasa pada masa kini. Namun begitu, produk ini tidak mendapat sambutan di Malaysia berbanding dengan Negara membangun. Ini adalah proses merekabentuk pemanas air solar menggunakan prinsip asas termodinamik iaitu radiasi, olakan, dan konduksi. Projek ini juga menggunakan proses untuk membangunkan produk dengan mengenalpasti keperluan produk dan Spesifikasi Rekabentuk Produk. Elemen Termodinamik juga terdapat dalam projek ini. Rekabentuk ini mempunyai tujuan yang spesifik di mana rekabentuk menjurus kepada pemungut cahaya solar yang efisien dan rekabentuk yang baik untuk meningkatkan tenaga haba yang boleh dipungut.

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LIST OF SYMBOLS

λ	=	wavelength
σ	=	Stefan–Boltzmann constant
α	=	Spectral absorption factor
ρ	=	Spectral reflection factor
τ	=	Spectral transmission factor
ε	=	emissivity constant
ν	=	Unit of frequency
Δ	=	Total sum
T	=	Temperature
b	=	Wien's displacement constant
A	=	Area
W	=	Power
h	=	Planck's constant
c	=	Speed of light

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CHAPTER I

INTRODUCTION

1.1 Project Background

Water heater is one of the most basic home appliances that are vital for the people throughout the world over. From burning wood and logs to the usage of coal, the hot water businesses were never clean in a sense of the energy options. The fact that the most abundant energy in the world is not the most used energy.

The ever arising awareness of energy efficient and environmentally friendly products nowadays leads to the discovery of renewable energy. This leads to the most basic of energy since the dawn of Earth, the Sun.

Solar radiation water heater is the answer of greener technology and energy efficiency. It comprises of a solar energy collector to heat up water for home appliances. This eliminates the need to use burners that uses fossil fuels or electrical sap of energy. Using this product, users enjoy a cut of electric bills and a chance to give back to nature too.

1.2 Problem Statement/ Definition

The use of electric or burner as the energy option for water heater has increasingly been causing the pollution and power shortage in the past. A greener world is now the dream of the people because of the natural threat of Global Warming phenomenon.

- a. Environmentally friendly options are there in the market but the option seem too expensive. A cheap solar powered water heater designed for everyday use need to be designed.
- b. This device is a variation of enhancement from the existing market.

1.3 Objective

The objective that needed to be achieved in this project is:

- a. To study and design a water heating system for home appliances using Solar Thermal Radiation
- b. To optimize the heating capacity of the new design

To achieve the above objective, a solar radiation water heater is to be fabricated to show that it would work. Data and information are gathered and used as reference in the development of this design. Product refinements are repeatedly done using simulations in CAD to perfect the end product and solve the problems faced in the process.

1.4 Scope of Studies

The following are the scope of study for solar radiation water heater:

- i. Literature/ Background Study
- ii. Theoretical Study
- iii. Concept Development
- iv. Study and Confirm Simulation Data
- v. Prototype Fabrication
- vi. Final Report Writing

CHAPTER 2

LITERATURE REVIEW

2.1 The Sun and Earth

The Sun is the star at the center of the Solar System. The Earth and other matter orbit the Sun. The mean distance of the Sun from the Earth is approximately 149.6 million kilometers, and its light travels this distance in 8 minutes and 19 seconds. The Sun is the one and only source of energy to earth. Thanks to the Sun, the Earth is able to flourish to be the Blue Planet it is today.

2.2 Solar Radiation

Solar Radiation is commonly known as Sunlight. It is the total spectrum of the electromagnetic radiation given off by the Sun. Solar radiation on Earth is filtered through the atmosphere, and is obvious at daylight when the Sun is above the horizon. Near the poles in summer, the days are longer and the nights are shorter or non-existent. In the winter at the poles the nights are longer and for some periods of time, sunlight may not occur at all. Sunshine is experienced as a combination of bright light and heat when the direct radiation is not blocked by clouds. Radiant heat directly produced by the radiation of the sun is different from the increase in atmospheric temperature due to the

radiative heating of the atmosphere by the sun's radiation. Sunlight is recorded by using a Pyranometer or Pyrliometer. The World Meteorological Organization defines sunshine as “direct irradiance from the Sun measured on the ground of at least 120 watts per square meters”. Direct sunlight has a luminous efficacy of about 93 lumens per watt of radiant flux, which includes infrared (heat), visible, and ultra-violet light.

Most places in Malaysia recorded normal to slight above normal solar radiation with some areas in southern Pahang recorded slight above normal solar radiation. In Figure 2.1 as shown, areas in Malaysian Peninsula received 16 to 20 MJm⁻² of daily solar radiation while areas in East Malaysia recorded 14 to 17 MJm⁻² of solar radiation per day. Sarawak had the lowest solar radiation throughout this period ranged from 14.0 to 16.0 MJm⁻². On the other hand, higher solar radiation was recorded in Penang, Perlis, Kedah, Central and Northern Kelantan and also Northern Terengganu with more than 20.0 MJm⁻² of solar radiation per day.

(Source: www.kjc.gov.my/english/publication/10ab_2.htm)

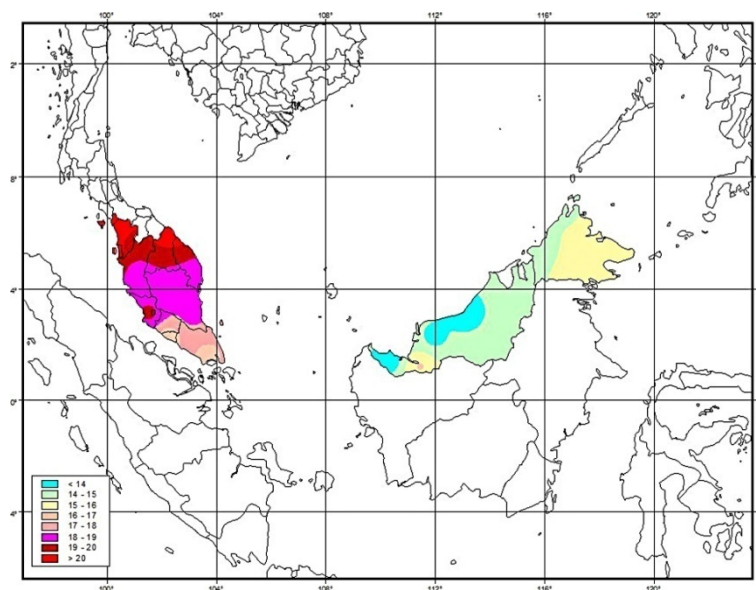


FIGURE 2.1: Solar Radiation in Malaysia

(Source: Kementerian Kaji Cuaca, 2009)

2.3 Heat transfer

Heat can be transferred in three different ways. It is conduction, convection and radiation. Ideally, all modes of heat transfer require the existence of temperature difference, and all modes of heat transfer are from the high temperature medium to a lower one. (Thermodynamics, An Engineering Approach Sixth Edition)

2.3.1 Thermal Radiation

Thermal radiation is electromagnetic radiation emitted from the surface of an object which is due to the object's temperature. An example of thermal radiation is the infrared radiation emitted by a common household radiator or electric heater. A person near a campfire will feel the radiated heat of the fire, even if the surrounding air is very cold. Thermal radiation is generated when heat from the movement of charged particles within atoms is converted to electromagnetic radiation. Solar radiation heats the earth during the day, while at night the earth re-radiates some heat back into space.

If the object is a black body, the radiation is termed black-body radiation. The emitted wave frequency of the thermal radiation is a probability distribution depending only on temperature and for a genuine black body is given by Planck's law of radiation. Wien's law gives the most likely frequency of the emitted radiation, and the Stefan–Boltzmann law gives the heat intensity. (Wikipedia, 2009)

There are three main properties that characterize thermal radiation:

- Thermal radiation occurs at a wide range of frequencies, even at a single temperature. The amount of frequency is given by Planck's law of radiation (for idealized materials).