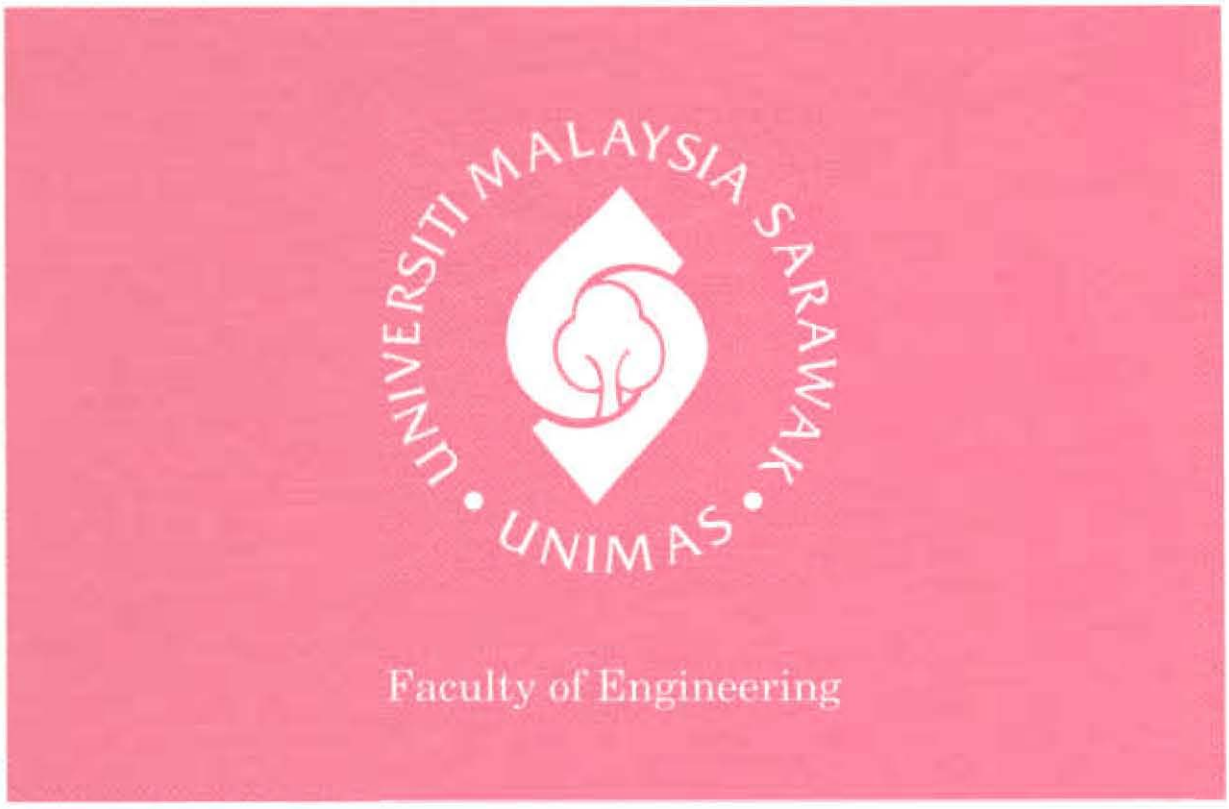

DESIGN OF CYLINDRICAL SOLAR WATER HEATER USING ALUMINIUM AS SOLAR COLLECTOR

Brandon Kho Chin Kheng

Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)
2010

UNIVERSITI MALAYSIA SARAWAK

BORANG PENGESAHAN STATUS TESIS

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SESI PENGAJIAN: 2006 - 2010

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MISS NUR TAHIRAH RAZALI — Date

Project Supervisor

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DESIGN OF CYLINDRICAL SOLAR WATER HEATER USING ALUMINIUM AS SOLAR COLLECTOR

BRANDON KHO CHIN KHENG

This project is submitted in partial fulfillment of

the requirements for the degree of Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

Faculty of Engineering

UNIVERSITI MALAYSIA SARAWAK

2010

Dedicated to my beloved family and friends, who always give me encouragement and support

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ABSTRAK

Pemanas air suria telah banyak digunakan oleh negara-negara membangun terutamanya di Eropah untuk mengantikan pemanas air suria. Di Malaysia, pengunaan pemanas air suria masih kurang mendapat sambutan kerana kurangnya pemahaman masyarakat dan kesedaran akan maanfaat fungsi dan potensi pemanas air suria ini. Menyedari akan masalah itu, tujuan kajian ini adalah untuk merekabentuk pemanas air suria jenis silinder dengan menggunakan aluminium sebagai pengumpul tenaga suria. Dua jenis bentuk pengumpul suria telah direka iaitu bentuk gulungan dan bentuk sirip masing-masing bersaiz 9mm diameter luar dan 8mm diameter dalam dimana ia dicat hitam dan ujian telah dilakukan keatas kedua-dua rekabentuk itu. Panjang keseluruhan untuk pengumpul gulungan adalah 5.3m manakala bagi pengumpul sirip adalah 1.1m. Suhu persekitaran, suhu pengumpul suria dan suhu air masuk dan keluar ditentukan oleh K-Type thermocouples dan laju aliran air adalah 2.4kg / jam. Prestasi dan ujian pemanas air suria telah dilakukan lima kali pada hari yang berbeza dari pukul 08:00-17:00. Suhu tertinggi air keluar adalah 58.3^{0}C yang dihasilkan oleh pengumpul gulungan. Kecekapan pemanas air suria silinder telah ditentukan dimana kecekapan harian maksimum yang diperolehi adalah 57,6% untuk pengumpul gulungan dan 45,7% untuk pengumpul sirip. Pengumpul suria bentuk gulungan boleh dituntut sebagai rekabentuk yang lebih baik daripada bentuk sirip. Hal ini menunjukkan kemampuan lebih baik dari sistem untuk menukar tenaga suria kepada haba yang boleh digunakan untuk memanaskan air.

ABSTRACT

Solar water heaters have been employed by many developed countries, especially in Europe, in order to replace the electric water heater. In Malaysia, implementations of solar water heater still in a small amount due to lack of public understanding and awareness of the working and potential benefits of Solar water heaters. Realizing those problems, the aim of this study is to design a cylindrical solar water heater using aluminium as the solar collector. Two designs of the solar collector were developed which are coil shape and fin shape with the tube inner diameter of 8mm and outer diameter of 9mm painted black, and testing experiments have been done on both design. The overall length for coil collector is 5.3m and fin collector is 1.1m. The ambient temperature, collector temperature and temperature of the inlet and outlet water were determined by K-Type thermocouples and the mass flow rate of water is 2.4kg/h. The performance and testing solar water heater has been carried out five times at the different days from 8 am to 5 pm. The highest water outlet temperature achieved is 58.3^{0}C which produced by coil collector. The efficiency of the cylindrical solar water heater was calculated where the daily maximum efficiency obtained is 57.6% for coil and 45.7% for fin collector. The coil shape collector can be claimed as better design than fin shape collector. This reveals a good capability of the system to convert solar energy to heat which can be used for heating water.

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ABBREVIATION

ASHRAE	- American Society of Heating, Refrigerating and Air Condition Engineers.
DAB	- Day Agromet Bulletin
DOE	- Department of Energy
EIA	- Energy Information Administration
ICS	- Integrated Collector Storage
IEA	- International Energy Agency
MMA	- Methyl Methacrylate
MMD	- Malaysian Meteorological Department
NASA	- National Aeronautics and Space Administration
PC	- Polycarbonate
PTC	- Parallel Tube Collector
PU	- Polyurethane
SEI	- Solar Energy International
SRCC	- Solar Rating & Certification Corporation

STC	- Serpentine Tube Collector
SWH	- Solar Water Heater
SWHS	- Solar Water Heating System
TIM	- Transparent Insulation Material
TPPC	- Two Parallel Plate Collector
US	- United States
WSP	- Worldwide Solar Power

NOMENCLATURE

A_c	Collector area
I_s	Solar intensity
Q_{out}	Heat output for water
T_{in}	Inlet temperature
T_{out}	Outlet temperature
$\dot{V}$	Water flow rate
θ_i	Incidence angle
C	Specific heat for water
η	Collector efficiency
I_{sc}	Solar constant

CHAPTER 1

INTRODUCTION

1.1 Overview

Nowadays, energy is the backbone of human activities. The importance of energy in economic development is very critical, as there is a strong relationship between energy and economic activity. The increment in global energy demands due to population growth and 20th century industrial revolution leads fossil fuel through a transitional phase (Shukla, A. et al, 2009).

World now faced with a grave crisis that may change people's way of life forever. People live in a civilization that evolved on the promise of an endless supply of cheap oil, which can be classified as non-renewable energy. The era of cheap oil will end, probably much sooner than most people realize.

The fact that nonrenewable energy resources will be available at the present usage level only for a limited period has been accepted worldwide. According to Wang, X.W and Ben, H. (2005), the world's total oil reserves will be depleted in early 21st

century. Natural gas can be of use to people 20 years more than oil. Coal will last for another 200 or 300 years.

Besides that, there are many more crises. Environmental problems due to people's blind exploitation and utilization of resources are severely threatening human's subsistence (Romero, J. et al. 2008). The consistently growing use of non-renewable will cause the depleting oil and gas reserves, global warming, green house gases etc. It is being widely realized that for sustainable development presently used energy mediums such as fossil fuel and nuclear power have to be quickly replace by renewable energy sources (SERC).

Therefore, the need for renewable energy resources becomes very urgent. As an absolutely clean energy, biomass, solar, wind, hydropower, and geothermal energy are of most importance and has been most emphasized on so far. They grouped under renewable energy because they are non-exhaustible and are available in abundance (Ong,K, 1994).

Renewable energy technologies promise a sustainable energy future as they are derive from sources that are infinite, inexhaustible, environmentally clean and widely distributed. From **Figure 1.1**, it has shown that almost all of the developing countries were implemented renewable energy.

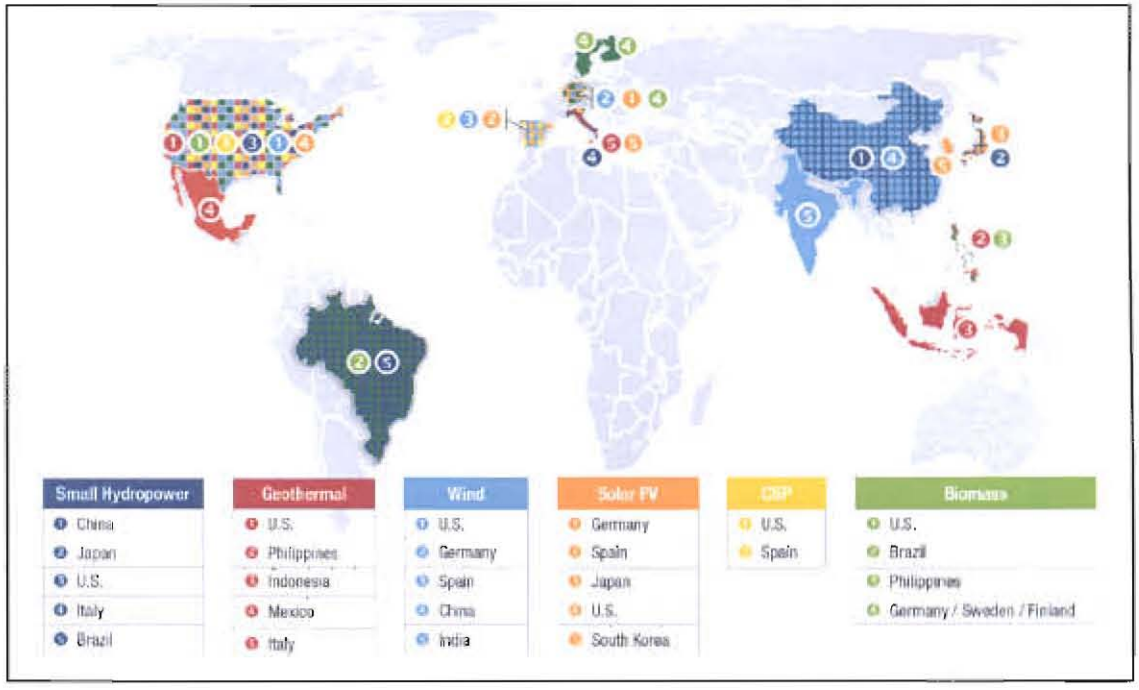

Figure 1.1: Top Countries with Installed Renewable Electricity by Technology (2008) (Courtesy of NASA, 2009)

1.2 Solar Energy

Nowadays, solar energy becomes one of the famous renewable energy sources in meeting the global energy demand (Ferreira, A.R et al). However, Hasnain, S.M et al (1998) found that the proper knowledge of solar energy is lacking in many levels of society. This void can be filled by putting hectic efforts to improve the overall understanding and knowledge of reliable and environmentally sound solar energy (Bourdiros, E., 1991).

Therefore, the U.S. Department of Energy (DOE) actively supports a broad range of activities that facilitate the commercialization and deployment of solar technologies through the "Solar Energy Technologies Program". Through this program, it will create awareness to the society about importance of the solar energy. These solar technologies such as concentrating solar power, photovoltaic, solar heating and solar lighting are commonly implemented (DOE, 2009).

In earlier days, solar energy found its use as a heating source. Solar energy has been used to heat water for many years. Since then, many uses of solar energy have been found out and now people consider solar power to be a major provider of electricity for their homes. Solar energy or power is the most important energy source that is popular, easily usable and most convenient among people all over the world, even more than the wind and the water energy. In addition, people from all lifestyles have benefited from the energy derived from the sun in one way or the other (WSP, 2006).

Besides, solar energy have the advantages of being an energy that is available throughout the globe, with environmental clean and inexhaustible. It is becoming an important alternative resource of renewable energy, while consuming fossil fuel severely leads to the problem of global warming (Hasnain, S.M., 1998). With continuous advancement in solar technology, solar energy promises to be one of the most effective ways to replace non-renewable energy. **Figure 1.2** stated the states leading solar energy development.

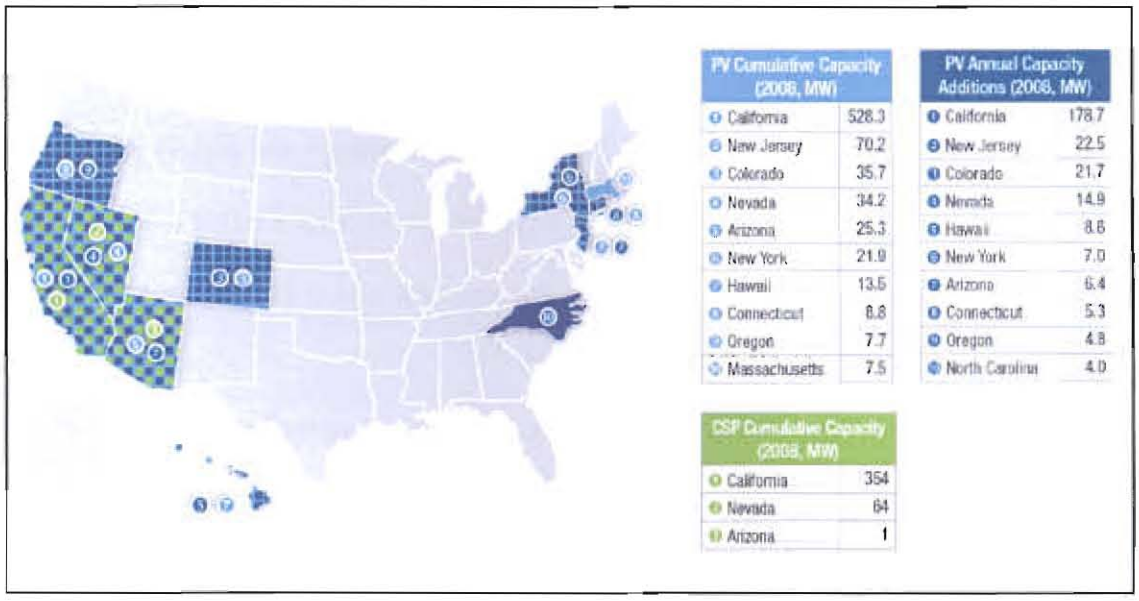

Figure 1.2: States Leading Solar Energy Development (Courtesy of NASA, 2009)

1.3 Overview of Solar Water Heating

A solar water heating system (SWHS) is an example that uses solar energy. Technical advances in solar water heating have increased very rapidly in the last 30 years. Solar water heating is one of the most successful and fast growing renewable technologies and has enormous potential in domestic, commercial and industrial applications.

Many solar water heater-heating systems have been in use since the time of Second World War. For applications up to 50 or 60 ^{0}C of water temperature, solar energy can effectively utilized for the domestic or commercial sector. (Bansal, N.K. et al, 1990)

At present, the use of solar water heater (SWH) in households become more prevalent due to their low electrical cost as compared to conventional electric heaters used. This system has a good economic payoff. Water heating can constitute up to 25% or more of a home's energy expenditures. By installing a solar hot water system, the annual operating costs to heat a home can be reduced by 50%-80% (SEI, 2009).

Solar water heaters have gained popularity throughout the world and are slowly replacing the conventional water heating systems in most part. They are proven to have many advantages over the conventional system (ArticlesBase, 2009)

The solar water heater has been proved to be commercially successful in countries like Israel, Japan, Australia, India and the United State, for providing 60 ^{0}C hot water for bathing and washing purpose (Ong, K., 1994).

However, application of solar water heater in Malaysia still in a small number. This is due to the high cost of the solar water heater and lack of knowledge in renewable energy among the publics. The price of the basic solar water heater now in the market is around RM 3800- RM5000 (Gading Kencana Sdn Bhd, 2006). Many people will think that prices are too expensive but they never think about the returns that they will gain when implementing SWH.

1.4 Objective and Scope of Study

Normally, the solar water heater in Malaysia is less implements domestically due to the implementation cost as a major factor and easily to install and relatively inexpensive to purchase electric water heaters. Malaysia has good climate condition, for development of solar water heaters households used. Therefore, the objective of this project is to design a cylindrical solar water heater using aluminium as thermal collector. Two different shapes of the collector will be developed. There are some criteria need to achieve in the design which are low capital cost, material available locally and easy maintenance. The scope of the study will investigate on the solar water heater performances which are:

i. Determine the outlet water temperature of the heating system
ii. Determine the solar water heating system efficiency
iii. Analyze which collector is more effective as a solar collector

1.5 Aim of Study

The aim for this study is to design a low cost, easy maintenance and materials or components are available locally solar water heater. Hence, this type of low cost solar water heaters is more affordable among householders particularly for a small size family to meet hot water requirements, concurrently reduce homeowner bills, and prevent

pollution. Besides, the collector tube designed will be of high efficiency collector in the sense that, the collector can achieve high performance in daytime temperature and heat water at constant, high rate.

1.6 Chapter Outline

This report is divided into five main chapters; Introduction, Literature Review, Methodology, Result and Discussion, Conclusion and Recommendations. The summary of the content for each chapter is as following.

Chapter 1 Introduction on why the project is carried out and the important of the project is discussed. The objective, scope and the aim of the project, and chapter outline is included in this chapter.

Chapter 2 Literature Review contains the history and the background of the solar water heating system and the renewable solar energy. The weather condition in Malaysia and the types of solar water heater available are discussed. This chapter also contains the previous study and research that done by researchers of the solar water heating system.

Chapter 3 Methodology will explain the methodologies use to achieve the objective of the project. This chapter cover about the considerations made in designing, type of experiment and testing that been done during designing, construction of the design and testing that will be done to evaluate the design.