PARABOLIC-TROUGH SOLAR WATER HEATER

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DISSERTATION SUBMITTED AS PARTIAL FULLFILLMENT
FOR THE DEGREE OF
BACHELOR OF SCIENCE WITH HONOUR

PHYSICS WITH ELECTRONICS PROGRAMME
SCHOOL OF SCIENCE AND TECHNOLOGY
UNIVERSITI MALAYSIA SABAH

MAY, 2008

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JUDUL: "Parabolic trough solar water heater"

IJAZAH: SARJANA MUDA KEJURUTERAAN (FIZIK DENGAN ELEKTRONIK)

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I declare that this research work is performed by me in the School of Science and Technology, University Malaysia Sabah as my final year project. All the information except the summary and creations which I have mentioned the resources are from my own writings.

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ACKNOWLEDGEMENT

I would like to acknowledge a number of people for their interest and commitment which helped me a lot to shape this research into its final form. First of all, I am really grateful to God for His mercy in giving me strength and patient throughout the duration of this project.

I extend my most sincere gratitude to my project supervisor, Dr.Haider F.Abdul Amir, for his unfailing cooperation and guidance since the beginning of this project. His constructive criticism and willingness to spend his time helping me were really appreciated.

My warmest thanks go to my beloved family, whose moral support has meant so much to me. I owe a debt of gratitude to my father Govindasamy S/O Ramasamy and also my mother Usha D/O Rengasamy for their loves and encouragement. They have been such wonderful parents and always been behind me all the way.

My special thanks go to all of my friends especially to G.Thayabaren, M.Thynakaran and T.Siva and my course mates N.Vigneswaran and S.Aravinthersena for their help to finish this project.

ABSTRACT

This study presents the parabolic-trough solar water heater in how much the heat absorbed by this water heater and the influence of the pipes along the trough. Black coated pipes can absorb more heat then the non-coated pipes. The advantage of parabolic-trough solar water heater compare to other shape of solar water heaters is, it can reflect the sun light to the focal point not considering position of the sun and the sun light falls. The most important thing in this parabolic-trough solar water heater is the focal point. The focal point must be at the right position so that the parabola shape can reflect the sun light towards the pipe along the focal point. The focal point in this research is at 5.3cm height from the mid-point of the parabola shape.

ABSTRAK

Kajian ini membentangkan penyerap haba parabola berbentuk 'U' dalam menyerap haba dan cirri-ciri paip yang dipasang selanjar dengan titik fokusnya. Paip yang diselaput warna hitam menyerap lebih haba daripada yang tidak diselaput warna hitam. Kelebihan penyerap haba parabola berbentuk 'U' berbanding dengan bentuk penyerap haba solar yang lain adalah, ia dapat memantulkan cahaya matahari terus kepada titik fokusny tidak kira di mana jua matahari berada dan cahaya matahari bersinar. Perkara yang paling penting dalam penyerap solar berbentuik 'U' ini adalah titik fokusnya. Titik fokus perlu berada di tempat yang betul supaya, bentuk parabola tersebut dapat memantulkan cahaya matahari ke arah paip yang dipasang di titik fokus.Titik fokus dalam kajian ini berada di ketinggian 5.3cm dari titk tengah bentuk parabola tersebut.

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°C	degree Celsius
ms^{-1}	meter per second
Mw	megawatt
kg	kilogram

CHAPTER 1

INTRODUCTION

1.1 Solar energy

Solar energy is the radiant energy that is produced by the sun. Every day the sun radiates, or sends out, an enormous amount of energy. The sun radiates more energy in one second than people have used since the beginning of time. Sun is a big ball of several of gases such as hydrogen and helium. The hydrogen atoms in the sun's core combine to form helium and generate energy in a process called nuclear fusion (Frank, 1990).

During this process the sun is extremely high pressure and temperature cause hydrogen atoms to come apart and their nuclei fuse to become one helium atom. But the helium atom contains less mass then the four hydrogen atoms that fused. Some matter lost during the nuclear fusion process (Eric, 1989). The lost matter is emitted into space as radiant energy. The solar energy travels to earth at a speed of $3x10^8$ ms^{-1} (the speed of light).

Though a small part of energy radiated by the sun into space which is 1 part in two billion, this is an enormous energy. About 15% of the sun's energy that hits the earth is reflected back to space (Liepert, 2002). Another 30% is used to evaporate water to produce rainfall. Solar energy also absorbed by plants, lands and the oceans. The rest of solar energy could be used to supply our energy needs such as water heating and generating electricity. The solar energy used in many kind of fields such as in heating water for domestic use, space heating of buildings, drying agricultural products and generating electrical energy (Cohen, 1993)

Solar hot water systems capture energy from the sun to heat water for homes and businesses, thereby displacing the use of natural gas, or in some cases electricity, with free and limitless solar energy (Eric, 1989). Solar water heater is a simple, age-old technology that is used around the world.

Solar collectors, usually placed on the roof of a home or business, absorb the sun's energy to heat water that is then stored in a water tank. The efficiency of the collectors can be as high as 87 percent, meaning very little solar energy is lost in the process (Stephen, 1992).

Many countries are encouraging increased use of solar hot water technology. Worldwide installations grew 14 percent in 2005, led by China with almost 80 percent of today's worldwide market. Solar hot water systems can reduce fuel usage for water heating, usually natural gas, by 75 percent or more in the buildings that employ them.

Solar water system also can reduce dependence on natural gas, bring down the price of gas for all consumers, and reduce global warming pollution (Price *et al.*,2002).

First commercially-available solar water heaters produced in southern California. Initial designs were roof-mounted tanks (Eric, 1989). Later, glazed tubular solar collectors were in thermo siphon configuration. Several thousand systems were sold to homeowners. There are many types of solar water heater such as:-

a) Parabolic-trough
b) Parabolic dish
c) Flat plate
d) Power tower
e) Tubular

Parabolic trough solar water heater is one the mostly used solar water heater around the world because the ability in absorbing more solar heat from the sun light. Besides that the parabolic trough evacuated tube solar collector is one of the main technologies currently used in the solar electric power generation (SEGS) plants (Price *et al.*,2002).

Parabolic trough solar water heating is a well-proven technology that directly substitutes renewable energy for conventional energy in water heating. Parabolic-trough collectors can also drive absorption cooling systems or other equipment that runs off a thermal load (Eric, 1989).

1.2 Purpose of Research

The purpose of this parabolic-trough solar water research is to provide a high quality solar water heater which can provide human beings hot water supply without using electricity. As we all know electric water heater consume a large amount of current which it cost very high.

By doing this research we can know that parabolic-trough solar water heater is a better water heater than flat panel or other shape of solar water heaters. In Malaysia there are more flat panel solar water heaters rather than parabolic-trough solar water heater.

In the end of this research we can conclude which solar water heater is more suitable to use in our country and which on can really cut down the cost.

1.3 Research Objective

The objective of this research is to create a parabolic trough shape solar energy absorber to heat the water inside the tube. On the other hand, the objective of this research is to find out the ability of materials such as copper, aluminum and PVC pipe in absorbing heat from sun (solar energy).

Other than this, by doing this research, we can find out how much the parabolic-trough shape can influence in reflecting the sunlight to heat the water inside the tube in the focus point.

This research also can determine the ability of the parabolic-trough solar collector in heating the water in the tube. Other than this we also can find out whether the black color coating will absorb more heat or not.

We also can compare the difference between other shape solar heat collector such as parabolic dish and flat panel solar collector with the parabolic-trough solar heat collector.

1.4 Scope of study

The scope of this research is to find out the amount of heat absorbed by the parabolic trough solar water heater in heating the water inside the tube along the focus point. Other than this, by doing this research we also can find out the suitable material to absorb heat.

1.5 Hypothesis

The hypothesis of this research is black coated pipe can absorb more heat than uncoated pipes. Other than this, the parabolic shape has the most suitable shape to reflect the sun light to the focal point more accurately.

CHAPTER 2

LITERATURE REVIEW

2.1 History

The solar energy collector was introduced as early as 7th century B.C., where people used to focus the sun light to ignite fire in their woods (Frank, 1990). In 1760s a Swiss naturalist called Horace de Saussure came up with a principal that a room, a carriage, or any other place is hotter when the rays of the sun pass through glass. So de Saussure ended up in doing an experiment regarding the principal to prove his theory where he built a rectangular box out of half-inch pine, insulated the inside, and had the top covered with glass, and had two smaller boxes placed inside. Once the box exposed to the sun, the bottom box heated to 109^{0}C (Thomas and Guven, 1993).

Though de Saussure couldn't explain exactly how the sun light can heat up the box. Actually the black inner lining absorbed the sunlight and converted it into heat. Though clear glass allows the rays of the sun to easily enter through it, it prevents heat from doing the same. As the glass trapped the solar heat in the box, it heated up. The hot

box has become the prototype for the solar collectors that have provided sun-heated water to millions since 1892 (Liepert, 2002).

In the 19th century, poor people have to chop down woods and used coal to heat the water. On the other hand the wealthier heated up water with gas manufactured from coal. Still, the fuel didn't burn clean and the heater had to be lit each time someone wanted to heat water. This is a very dangerous process because if someone forgets to extinguish the flame, the tank would blow up (Kalogirou, 2004).

So in this century, the handy farmers or prospectors or other outdoors men devised a much safer, easier, and cheaper way to heat water which is placing into the sun a metal water tank painted black to absorb as much solar energy as possible. These were the first solar water heaters on record (John, 1980). But then the defect of this solar collector is the tank can lost their heat once sun went down because they had no protection from the night air.

The first solar solution in the world was invented in the year 1891. Clarence Kemp patented a way to combine the old practice of exposing metal tanks to the sun with the scientific principle of the hot box and increased the tank's capability to absorb solar heat (Jessop, 1983). He named his invention Climax. It was the world's first commercial solar water heater. The solar water heater, Kemp advertised, would simplify housekeeping duties such as lighting the gas furnace or stove to heat water.

Followed by this invention, in California and other such temperate states, having greater amounts of sunshine throughout the year and higher fuel costs (than in places like Maryland) made it essential for residents to take their solar assets seriously and not waste them. The Climax sold well in such areas. Sixteen hundred had gone up in homes throughout Southern California by 1900.

But the problem is the heated water will turn cold at the night time by the cold air. In 1909, William J. Bailey patented a solar water heater that revolutionized the business. He separated the solar water heater into two parts which is a heating element exposed to the sun and an insulated storage unit tucked away in the house so families could have sun heated water day and night and early the next morning. The heating element consisted of pipes attached to a black-painted metal sheet placed in a glass-covered box (Ozisik, 1977).

Bailey reduced the volume of water exposed to the sun at any single moment and therefore, the water heated up faster. Providing hotter water for longer periods put Bailey's solar hot water heater, called the Day and Night, at a great advantage over the competition. Soon the Climax went out of business. From 1909, when Bailey started up his business, through 1918, his company had sold more than 4,000 Day and Night Solar Hot Water Heaters.

Huge discoveries of natural gas in Los Angeles during the 1920s and 1930s crashed the local solar water heater industry (Ozisik, 1977). So, Bailey the inventor of Day and Night Solar Hot Water Heaters had applied some changes and created

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