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Design and Testing of Solar Water Heaters with Its Calculation of Energy

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Abstract: Today there are different technologies for designing and manufacturing solar water heating (SWH). In the past, the sun's energy was used to heat water, for its important applications and because solar water heaters became most important in our life and to increase usage of sources of renewable energy, therefore; the current work is to design, manufacture and test of solar water heating system. The objective was to study the annual cost of operating a SWH and to make comparison between it and annual cost of the operation of an Electric Water Heating system. The results of this study were tested and reported of the higher temperature which reached of 88.8^0C. These results if compared with other devices were very good results, because the cost of current design was 37 OR (USD 100). In addition, the position is important parameter to get high temperature (to make SWH face to the sun).

Keywords: Solar energy, Heater, Temperature and Renewable energy

1 INTRODUCTION

The sun is a huge emission source of energy which is prepared as light or heat, for that we can use it in alternative of Non-renewable energy to generate electricity, heating, cooling and lighting buildings. And this sun radiates is approximately 174423E9 KW per hour .There are many applications of renewable energy such as sunlight, tide, wind, rain, geothermal heat and solar energy. Solar energy consists of solar electricity and solar thermal energy which are an important use of solar energy

Because so much sunlight is concentrated in a small area, the tower fluid becomes superheated, reaching 650° Celsius [1]. These higher temperatures help to reduce the cost of thermal storage. Also, the heliostats used in central receivers are nearly flat, rather than curved, reducing their manufacturing cost [2]. These features combine to give central receivers the potential to be produced inexpensively [3]. A major benefit of a CSP plant is that its fuel comes directly from the sun. This is a renewable energy source that has the added benefit of being completely free to harvest [4]. The generation of electricity through CSP produces few, if any, harmful atmospheric emissions. Since the energy source comes directly from the sun, there is no destructive extraction process [5]. There is also no combustion process when generating power with CSP, which eliminates the issue of hazardous emissions [6]. In most electric generation systems, the fuel must be combusted to release heat for use in generation [7]. With CSP, energy from the sun is directly utilized for the heat used in the electricity generation process. This lack of a conversion step is a key component of what makes CSP such a clean energy source [8].

2 APPROACH AND METHODS

In fact there are many designs for solar water heating systems such as direct flow design, parallel flow design, web flow design; spiral flow design and modified serpentine. Parallel flow design which used in current design

To build our design, the design needs the following equipments:

a) Soft copper tubing with 1cm diameter (because copper is good conductor of heat)
b) Water containers(Tank) for output water
c) Galvanize iron sheet
d) Glass sheet
e) Elbows
f) Paint
g) Copper pipes
h) Naples
i) T-function
j) Flexible pipes
k) Metal sheet to make tank.

The dimensions of this system should be created to know exactly size of the raw material that needs it as follows:

- Length of frame: 970 mm

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- Width of frame: 590 mm
- Height of frame: 100 mm
- Pipes: 10 mm diameter (decrease diameter of pipe will take small amount of water which will heat faster than big amount of water)
- Length of pipe: 510 mm.
- Number of T-function was (97-7,leave a space between collector and frame, each side 3.5cm)
- Number of T-function was 15 for each side
- Two elbows (one each side).Therefore, number of T-function we need to our design for each side was 14 (15 T-function - 1elbow)
- Total Number of T-functions = 14 × 2 = 28
- Total Number of elbows was 1 × 2 =2
- Total Number of pipes was 14 (T-functions) +1(elbow)

Dimensions of the tank for input flow of water were as follows:

- Length of tank = length of frame = 970 mm
- Height of tank = height of frame = 10 mm
- To get a volume of water equal to (0.0291 m^3) the width of tank:
- W = V / (L × H) = 0.0291m^3 / (0.970 mm × 0.1mm) = 0.3 m = 30cm
- Output tank: Diameter of 25cm and length of 39 cm
- The manufacturing process can be divided to the following steps:

I. Plastic cover was removed from copper pipes(Figure 1)

Figure 1- Copper pipes

II. Cutting and measured the length of all pipes to required length (510mm) (Figure 2)

Figure 2- Cutting and measured the length

III. Prepare a frame by using plates saw machine, cutting, milling and drilling machines (Figure 3).

Figure 3- Prepare the frame

IV. Pipes were connected with T-function (each side) by use a piece of copper pipe (4cm) as show in the Figure 4 below.

Figure 4- Pipe connected with T-function

V. After finishing collect all 15 pipes, size of connected pipes was checked again and suitable

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to the frame. valve was connected with input pipe (Figure 5).

Figure 5 - Collection the pipes in the frame

VI. Then, all pipes with T-function (net of pipes) were tying them using adjustable (Figure 6)

Figure 6- Net of pipes

VII. Hydraulic test was done to check if there is a leaking in the pipeline (Figure 7)

Figure 7- Leaking test of pipes

VIII. Next, a tank of input flow of water was made with metal sheet. First, a rectangular of metal sheet with 97cm length, 30cm width and 10cm height was cut using a special seizure. Two holes were made in two side of the tank (one for source water and other for input flow to net of pipe). The tank was tested by fill it with water to know if there is any leak and welded it with the main frame of our design (Figure 8).

To make the system faced to the sun, angle by angle plate was made. Therefore, it was needed 4 plates with 90.4cm length, 2 plates with 54cm length and 3 plates with 97cm length. All of these plates were cut using cutting machine. Flexible pipes; input tank, net of pipes and output tank were connected to give us final shape of our design.

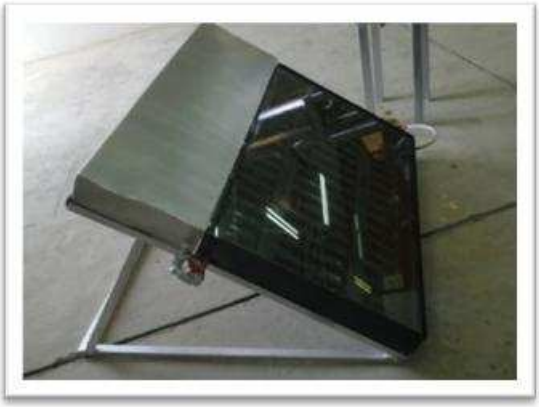

Figure 8- Final shape of design

3 ADVANTAGES AND DISADVANTAGES

There are many advantages of the system, which can be summarized as follows:

1. It is readily available to everyone because sunshine is free.
2. Solar energy has a positive impact on the environment (because it is non-polluting) by reducing the use of nonrenewable energy sources to heat water, such as gas, coal, oil or nuclear power.
3. This system is safe, efficient and reliable.
4. This device has no electrical shocks and burning accidents.
5. No moving parts and it can give along life, no need maintenance every day and it can be installed on roof or terrace or in balcony, hence, no additional space for installation.
6. In addition, solar energy saves cost. People use a lot of energy and many spend

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each month just in heating and powering their home.

On the other hand, there are few disadvantages of this design:

1. The upfront cost (initial cost, if you receive it from the companies) is very large because of the high cost of supplies.
2. The solar water heater worked in the morning only and it is influenced by the presence of clouds or pollution in the air.
3. The efficiency of the system is low.

4 RESULTS AND DISCUSSION

Many tests were done on solar water heater (SWH) at Sohar City, Sultanate of Oman to measuring the temperature of outlet water and inlet water with a deferent times starting from 10.00 am until 5.00 pm as shown in Table 1. From this Table, the results noticed the highest outlet temperature was 88.8 ^{0}C at 1:30 pm, the highest values of temperature reached between 1.00 pm and 2.00 pm

Table 1- Test Results starting from 10.00 am to 5.00 pm at Sohar city, Sultanate of Oman

Time	Inlet Temperature **T(^{o}C)**	Outlet Temperature **T (^{o}C)**
10 am	35	45.7
11 am	38.5	50.6
12 noon	40.8	69.5
12.30 pm	41.2	75
12.45 pm	43.2	77.5
1.00 pm	43.5	79.3
1.15 pm	43.6	80.2
1.30 pm	43.7	88.8
1.45 pm	43.8	86.3
2.00 pm	43.8	82.2
2.15 pm	43.6	78.4
2.30 pm	42.6	75.8
3.00 pm	42.5	73.5
4.00 pm	40.8	67.6
5.00 pm	38.1	62.2

The compression between the current study and other design which was double layer design, the double layer design has the best result and the highest temperature was 91.5 ^{0}C at 1.30 pm. The study was done in the same place at Sohar city, Sultanate of Oman by same researchers. Their objective was to study the annual cost of operating a SWHS and to make comparison between it and annual cost of the operation of an Electric water heating system. The same procedure for calculating annual cost in reference [9] has been adopted. In general, taking the concept of time value of money in consideration, then the annual cost (*AC*) of a system can be expressed as the following equation:

$$AC = IC + AFC + AMC \quad (1)$$

Where IC is the initial cost, AFC is the annual fuel cost, and AMC is the annual maintenance cost.

The Figure 8 shows their system. They reported their results of outlet and inlet temperatures during the day. They listed their results in the Table 2.

They found the amount of solar energy from the sun was 642.44 MJ and considering that the sun shines approximately 12 hours daily in Oman, which could be more than enough for the usage of Omani families. Then, they calculate the annual cost of the electrical water heater EWH and the annual cost of the SWHS. They found the annual cost of the electrical water heater (EWH) became greater than the annual cost of the SWHS as shown in Figure 9.

Table 2: Outlet and inlet temperatures during the day

Time (h:mm)	T_{in} (^{o}C)	T_{out} (^{o}C)
09:15	35.2	67.4
11.30	46.1	79.5
13:30	67.3	92.3
15:05	55.3	85.2
17:15	40.0	65.7

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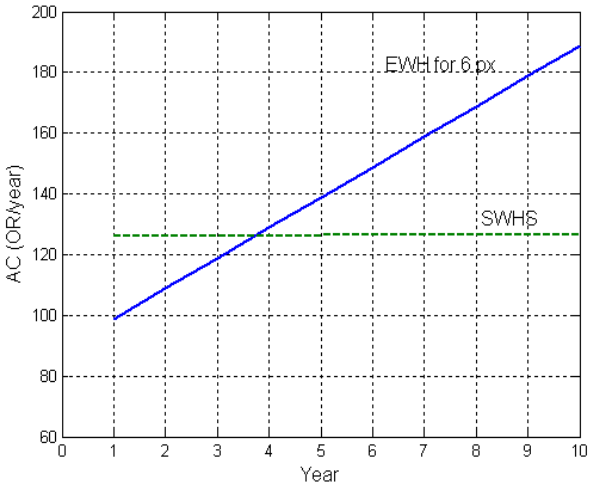

Figure 9 - Comparison of annual cost of 6 persons SWH with EWH.

The annual cost of 6 persons SWH has been compared with EWH. It is found that for the first 4 year EWH is cheaper than SWH but after that the SWH become cheaper due to the extra expanses of electricity added to the EWH expenses.

5 CONCLUSION

This paper presented design and test of SWH. Moreover, the system energy has been calculated. From this study, it can be concluded as follows:

1. To reduce the sources of nonrenewable energy by using sun emission which is kind of renewable energy SWH could be good option. As we know, renewable energy consists of different types; one of these types is such as sunlight. SWH is a type of thermal energy system which converts sunlight to heat which will give us hot water. The current work of SWH include of collectors and tank. In addition this system was passive. However, after finished this design and testing, there are some parameters which effect on increasing temperature, such as, type of design, materials, position and place. Furthermore, there were some difficulties when manufactured SWH.
2. The results of this study noticed that the highest outlet temperature was 88.8 ^{0}C at 1:30 pm, while the highest values of temperature reached between 1.00 pm and 2.00 pm.
3. Finally, according to the design and cost calculation awareness of public toward using SWH is important to get long-term economical benefits, environment friendly and to reduce this country's dependence on foreign oil that its price increase day after day.

REFERENCES

[1] Mousazadeh, H., 2009. A review of principle and sun-tracking methods for maximizing solar systems output. *Renewable and Sustainable Energy Reviews* 13 (8), pp. 1800-1818.

[2] Zhai, H., 2010. Experimental investigation and analysis on a concentrating solar collector using linear Fresnel lens. *Energy Conversion and Management* 51 (1), pp. 48-55.

[3] Shuang, Ying W., 2010. A parabolic dish/AMTEC solar thermal power system and its performance evaluation. *Applied Energy* 87 (2), pp. 452-462.

[4] Singh, P. L., Sarviya, R. M. & Bhagoria, J. L., 2010. Heat loss study of trapezoidal cavity absorbers for linear solar concentrating collector. *Energy Conversion and Management* 51 (2), pp. 329-337.

[5] Ortega, J. I., Burgaleta, J. I. and Tellez, F. M., 2008. Central receiver system solar power plant using molten salt as heat transfer fluid. *Journal of Solar Energy Engineering-Transactions of the ASME* 130 (2).

[6] Gottsche, J., 2010. Solar concentrating systems using small mirror arrays. *Journal of Solar Energy Engineering* 132 (1).

[7] Collado, F. J., 2008. Quick evaluation of the annual heliostat field efficiency. *Solar Energy* 82 (4), pp. 379-384.

[8] Liu, Q. B., 2010. Experimental investigation on a parabolic trough solar collector for thermal power generation. *China-Technological Sciences* 53 (1), pp. 52-56.

[9] Al-Hamadani, O., Kazem, H. A., Al-Mansoori, M. H., Ambusaidi, K. A., Hasoon, F., Al-Ajmi, M., Al-Sheidi, S., Al-Waeli, A. H. A, Al-Breiki, M., 2011. Economic Feasibility of Solar Water Heating Systems in Oman. *Caledonian Journal of Engineering* 7 (1), pp. 6-11.