(IJAER) 2018, Vol. No. 15, Issue No. III, March e-ISSN: 2231-5152, p-ISSN: 2454-1796

DESIGN CONSTRUCTION OF A SOLAR WATER HEATER DOMESTIC USE

B. Damodarakedillya
Lecturer in Mechanical Engineering,
Swami Nityananda Polytechnic College, Kanhangad,
Kasargod, Kerala.

ABSTRACT

Solar water heating systems and their applications are investigated. Water is now used for domestic, commercial, and industrial purposes. To heat water and produce steam, various resources such as coal, diesel, and gas are used. Solar energy is the primary replacement for traditional energy sources. The solar thermal water heating system is the technology used to harness the abundant free solar thermal energy. The solar thermal system is intended to meet the energy requirements. The size of the systems is determined by the availability of solar radiation, the temperature requirements of the customer, the geographical location of the solar system, and other factors. As a result, the solar water heating system must be designed in accordance with the aforementioned parameters. The available literature is reviewed in order to comprehend the solar thermal system's construction, arrangement, applications, and sizing. By implementing structure ideas such as source code reuse, one can create a total domain to assess sun-oriented vitality data. Area warming, residential small scale applications, and business large scale structures are all examples of heating applications for coordinated advancements. Warm capacity will most likely end up being critical to vitality proficient warming. A stratified boiling water tank will play an important role in the combination of a few warming advances that work effectively at various levels of temperature with lower execution costs. This paper depicts and evaluates the 'Water Snake,' a novel ease idea of a stratified high temp water tank. The results show that using this innovation, the new idea could provide productive stratification with little to no effort.

Keywords: *solar water heating system; Active & Passive system temperature controller; mass flow rate; delivery temperature; required temperature*

INTRODUCTION

A solar water heater is also referred to as a ‘solar thermal system’. This device is used to reduce energy dependence because the majority of our energy is generated by the combustion of fossil fuels, which causes a wide range of environmental issues. So, why jeopardise our environment when we can harness the sun's free energy?

Simple equipment is required to capture the heat of the sun in order to use solar energy. Solar water heaters use this free energy to heat water. The heated water can be used for a variety of purposes, including bathing, cleaning, and washing. Installing a solar water heater provides limitless clean energy while lowering electricity costs.

Before solar energy can be used in a practical heating or cooling system, it must be converted from the sun through space to the earth via electromagnetic radiation. Because solar energy is relatively dilute when it reaches the earth, the size of a practical system used to convert it to heat must be relatively large. Solar energy collectors, or devices that convert the sun's radiation to heat, typically consist of a surface that absorbs radiation efficiently and converts this incident flux to heat, raising the temperature of the absorbing material. A portion of this energy is then removed from the absorbing surface via a heat transfer fluid, which can be liquid or gaseous. One of the simple forms of solar energy collectors built is the flat-plate collector. It differs in several respects from more conventional heat exchangers. The later usually accomplish a fluid-to-fluid exchange with high heat transfer rates but with emitted radiation as an unimportant factor.

In the 1920s, flat plate collectors for solar water heating were popular in Florida and southern California. Photographic style Due to the abundance of sunlight, Israeli solar water heater was the first commercial company to manufacture solar water heaters, which were used by 20% of the population by 1967.

Solar energy is light that takes the form of electromagnetic radiation. Electromagnetic radiation is a wave-like phenomenon that transports energy over a long distance.

Solar energy is the most abundant and sustainable source of energy available to humanity. Solar energy is not currently used as a primary source of fuel energy, but a large research and development effort is underway to develop cost-effective systems to harness solar energy as a major source of energy, particularly for building heating and cooling.

Solar has the following advantages: I it is visually appealing; ii) it is non-polluting; iii) it is non-deflectable (not easily used); and iv) it is reliable and free.

Solar energy, on the other hand, has this disadvantage.

It is not constant for terrestrial use.

In their separate conversion processes, solar energy can be converted directly into the following forms of energy:

1) THE HELIOTHERMAL PROCESS: The only solar conversion that has a theoretical conversion efficiency of 100% is the absorption of solar radiation and conversion of the energy into thermal energy.
2) THE HELIOCHEMICAL PROCESS: The photosynthetic reaction is represented by this process. The sources of the reaction are all biomass and fossil fuel.
3) THE HELIOELECTRICAL PROCESS: This is the process by which electricity is generated using photovoltaic or solar cells.

The rate at which solar energy arrives at the earth is estimated to be 1.72 x 10MW. The incident solar energy on a horizontal surface ranges from 3.5 to 7kwh/m2/day. Approximately 30% of the

(IJAER) 2018, Vol. No. 15, Issue No. III, March **e-ISSN: 2231-5152, p-ISSN: 2454-1796**

total amount is reflected to space, 47% is converted to low temperature heat and reradiated to space, and 23% powers the biosphere's evaporation/precipitation cycle. Wind and wave kinetic energy, as well as photosynthetic storage in plants, account for less than half of the total.

USE OF SOLAR ENERGY

Solar energy has been used for a variety of purposes over the years, from drying cloth and agricultural products to sun tanning the body and, of course, food preservation. Air conditioning for cooling and heating of a building for human comfort using an absorption cooling system is another application of solar energy.

Other applications of solar energy include solar coolers, pool heating, engine pumps, solar furnaces, and electricity generation. [1-5]

PRINCIPLE OF OPERATION OF A SOLAR WATER HEATER:

Solar radiation passes through the glass in front of the absorber plate and strikes the absorber plate's flat black surface, where it is absorbed as heat (i.e., by increasing the internal energy). As a result of the flat-plate collector becoming extremely hot, the water contained in the risers and headers bound to the plate absorbs heat via conduction. The water inside the tubes (risers/headers) expands, making it less dense than the cold water from the storage cylinder. According to the thermosyphon principle, hot water is pushed through the collector and rises by natural convection to the hot water storage tank, while cold water from the cold water tank simultaneously descends to the collector's bottom header by gravity pull. As a result of the increased temperature and volume of the warmer water to the hot water storage tank, there is circulation. The circulation continues as hot water exits and cold water enters. Solar water heaters based on the thermosyphon principle have the following advantages: simplicity and low cost, no electrical supply required, no controller or pump required, easy to instal, can withstand mild sub-zero temperatures, is reliable and long-lasting because there are no moving parts, scalable (multiple collectors can be connected in parallel to increase hot water supply), easy to build and operate, no fuel cost, provides heated water of about 70 °C or within the range [6]

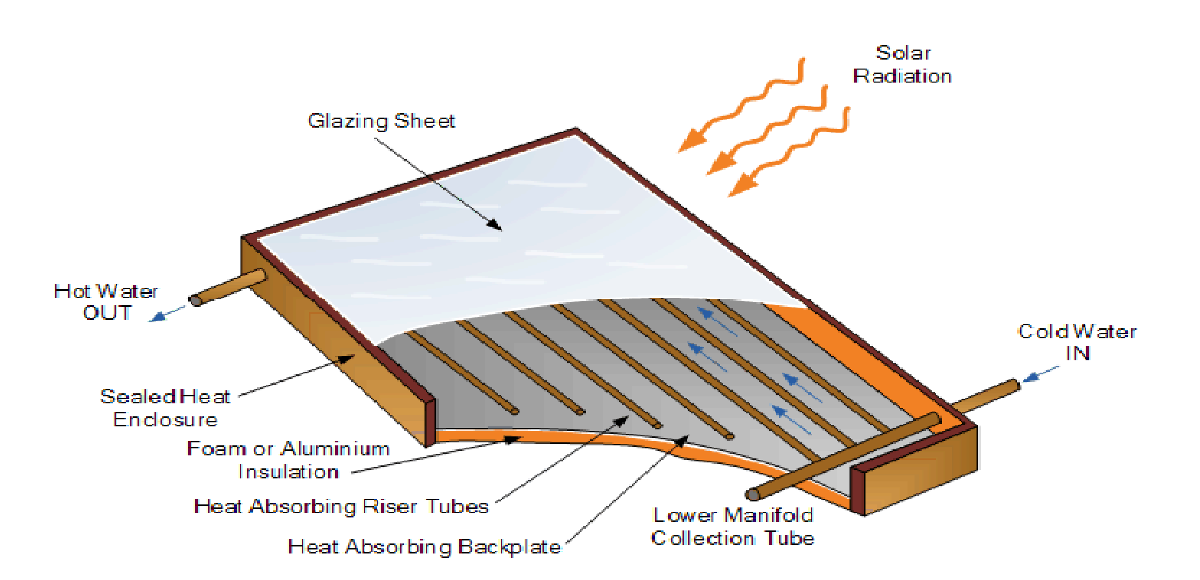

Figure : Typical flat-plate solar collector

Main Components of a Flat-Plate Solar Water Heater: [7-8]

Storage Tanks:

Solar water heating systems necessitate the use of a storage tank to hold the heated water. These tanks must be properly insulated to minimise heat loss. Insulation also contributes to increased efficiency. Heat losses should be eliminated from all sides of the tank; some insulation materials include sawdust, wood shavings, glass wool, and Styrofoam.

Flat-Plate Collector:

A solar collector is the most important part of a solar water heating system. It collects solar radiation, converts it to heat energy, and transfers it to the working fluid (water), which is then transported to a storage facility for later use.

The absorber plate:

The most common absorber plate materials are aluminium, copper, and mild steel. To increase the rate of solar radiation adsorption, the absorber plate is usually painted black. Because of its high thermal conductivity, copper is the best material for an absorber plate, but it is also the most expensive.

The flow channel:

This is typically made of copper, but galvanised steel pipes can also be used due to their rigidity and corrosion resistance. As it passes through the pipe, the working fluid absorbs heat energy. Depending on the design, the flow channel can be above or below the absorber plate.

Design And Building Process:

The formulation of the problem statement is the first essential and fundamental feature of this process. The design problem statement is created by determining the system's requirements, the given parameters, the design variables, any limitations or constraints, and any additional considerations arising from safety, financial, environmental, or other concerns. [9]

- No pumps are allowed in the solar water heating system. It should make use of thermosiphon effects.
- Solar collector controls - the control system is used to optimise the solar collector's sun exposure. The system is based on the fact that when sunlight strikes the solar collector at a 90° angle, maximum sun exposure is obtained. To achieve optimal exposure, a mechanical system will be designed to rotate and control the angle of exposure of the solar collector. This mechanical system will be designed in such a way that a rotational motion device initiates the solar collector motion via an electronic device input. The motion is initiated by the electronic device (microcontroller or programmable logic controller (PLC)) based on information obtained about the position of the solar collector relative to the sun.
- All system components must be visible and instrumented with thermocouples and flow rate metres. As previously stated, the finished product will serve as an instructional laboratory apparatus for demonstrating solar water heating and the thermosiphon concept.
- The material must withstand flow and temperature variations and be corrosion resistant.
- To reduce costs, heating system components such as tubes and fittings must be standardised.
- Mobility - the system will be used for demonstration purposes and will need to be exposed to direct sunlight. As a result, the system must be mobile and capable of being placed in direct sunlight. When not in use, the system must also be designed to be stored.

Objectives:

1. Create a solar water heater.
2. To build the solar water heater.
3. Conduct a performance evaluation of the built-in solar water heater.

REVIEW OF LITERATURE

Ogueke et al. conducted a review of solar water heating systems for domestic and industrial applications and classified them into two broad categories (passive and active), with each operating in either direct or indirect mode. They reported on their performance, uses and applications, and the factors that influenced their selection. Active systems have higher efficiencies, with values ranging from 35% to 80% higher than passive systems. They are more complicated and costly. As a result, they are best suited for industrial applications with high load demand, applications where the collector and service water storage tank do not need to be close to each other, and applications where the load requires more than one solar collector. Passive systems, of which this work is an example, are less expensive and easier to build and instal. They are best suited for domestic use and applications with low to medium load demand. [10]

(Hasan, 1997) investigated the effect of storage tank volume and configuration on thermosyphon SWH efficiency. This was accomplished by simulating the SHW with the TRYNSYS programme. The tank configuration was discovered to have no effect on system performance. [11]

(Zeghib & Chaker, 2011) designed a solar water heating system that included a 2 m^2 flat-plate collector and a 200-litre storage tank. The effect of thermosyphon flow and tank thermal stratification was studied using simulation software. (Zeghib & Chaker, 2011) concluded that a stratified storage tank has the advantage of producing more heat energy than a conventional fully mixed hot water storage tank. [12]

Good quality water is gradually becoming out of reach for most developing-country households. This is due to low income earnings in comparison to the ever-increasing cost of other energy sources for water disinfectant such as kerosene and firewood. Chloride solution concentrate has been reported to be an effective method of cleaning vessels for water disinfection and disease prevention. It does not, however, prevent recontamination. As a result, it was suggested that efforts be made to protect water after treatment up until the point of use. WHO recommended a residual chlorine concentration of 0.2 to 0.5mg/L to achieve this. The option is viable in areas where public water supply is available. This is far from reality in developing nations due to the collapse of public water supply systems. [13-14]

Most rural and semiurban communities do not have the "privilege" of being connected to the national power grid. Where they are linked, the erratic supply necessitates the procurement of a less expensive and more reliable source of energy, particularly for water pasteurisation. Solar energy is a free, limitless, and environmentally friendly resource [15-16].

RESEARCH METHODOLOGY

We used secondary information gathered from books, educational and advancement journals, govt. documents, and print and online reference resources to learn about the composition, use, and impacts of solar water heater design construction.

RESULT AND DISCUSSION

The buoyancy-induced flow of heated water in from the solar collector determines the temperature in the storage water tank. Because of the very slow buoyancy-induced flow rate, a heated water front will move downward through the tank. The rate of progression is determined by the magnitude of the thermosiphon effect. Figure 2 depicts the temperature variation in the water storage tank.

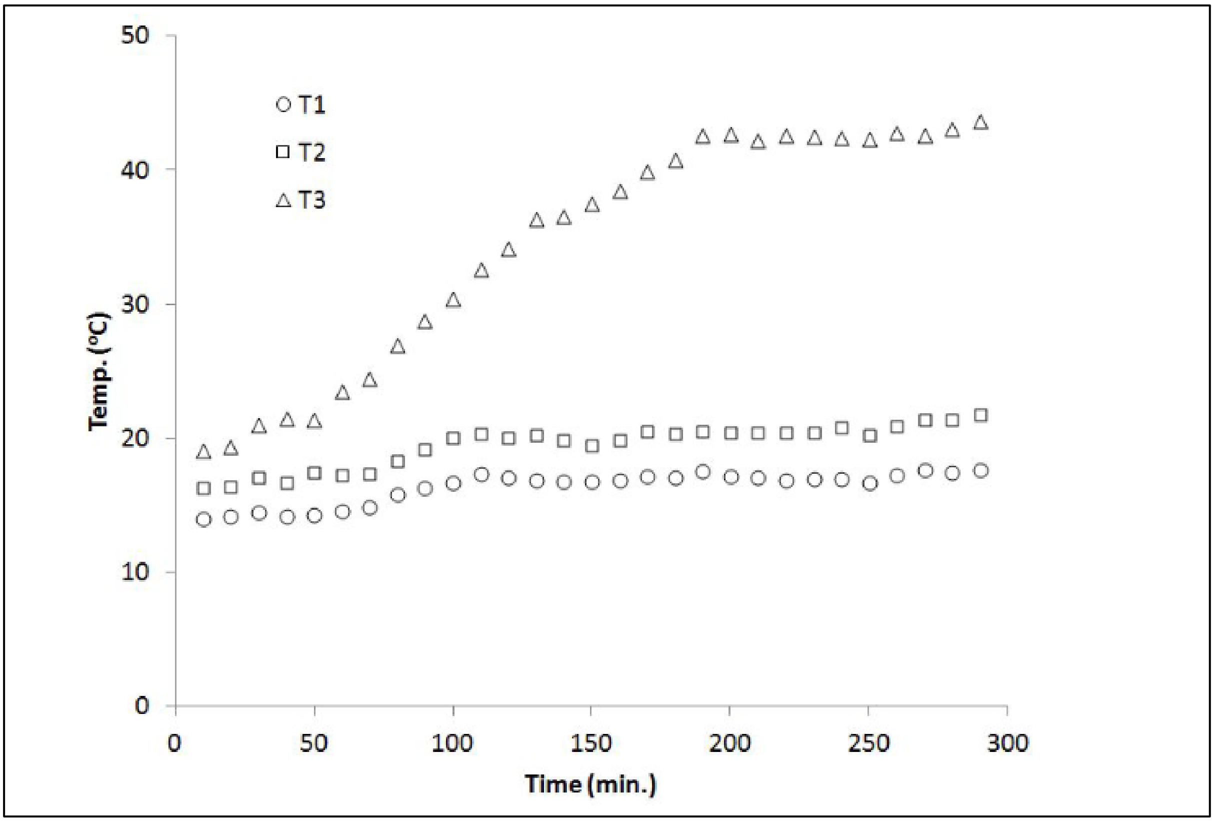

Figure 2: Temperature variation in the storage tank in heating water

T1 is the temperature of the water in the middle of the tank, T3 is the temperature of the water at the top of the tank, and T2 is the temperature in between the two. The temperature distribution increased during the operating time, as shown in the graph. It should be noted that the temperature of the water was also measured at two additional locations below T1. The temperature measurements at these two locations, however, are not shown in the figure because they changed little during the testing process. This indicates that the thermal stratification was well preserved. [17]

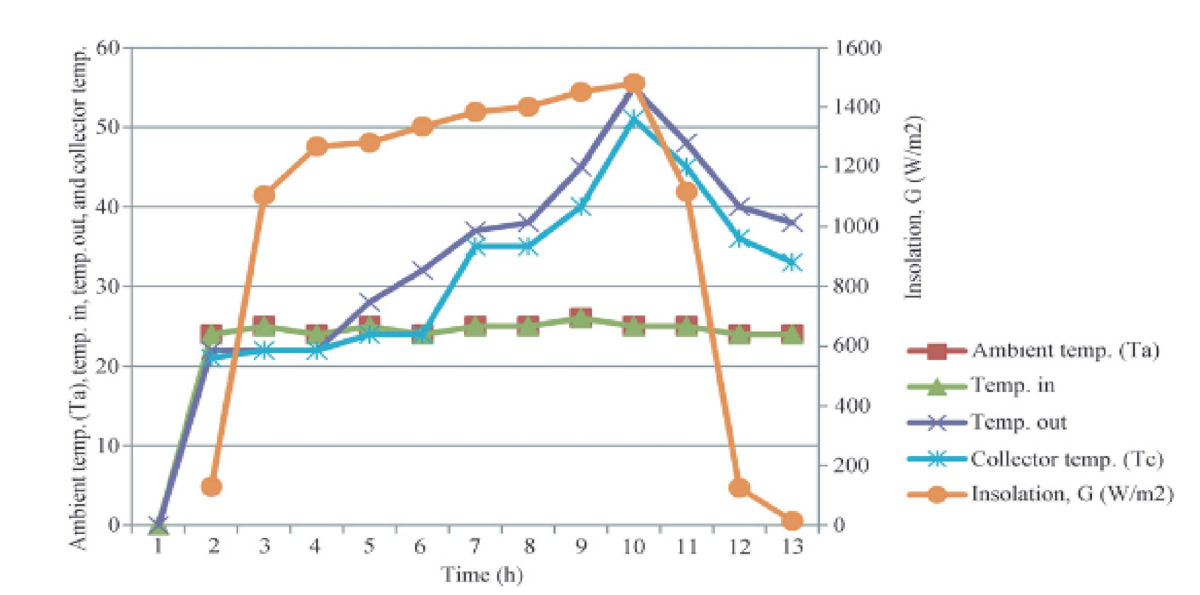

Figure 3: System temperature variation and daily solar

Figure 3 depicts the system's test results on a typical sunny day. The results showed that the ambient temperature ranged between 24 and 26 degrees Celsius. Between noon and 4:00 p.m., the maximum fluid (water) output temperature and collector temperature were measured. The insolation rose from a low at 7:00 a.m. to a high between noon and 3:00 p.m., then fell back to a low. [18]

CONCLUSION

A solar water heater is a long-term investment that can save us money and energy for many years. Solar-powered water heaters, like other renewable energy systems, reduce the environmental impact of living a comfortable, modern lifestyle at a lower cost because they do not have the hazards introduced by fossil fuels but are environmentally friendly and almost completely cost free to operate. Because of the thermosyphon principle, the system designed in this work requires little or no maintenance. It was primarily made from locally available raw materials. It has no moving parts and almost everything works automatically, but there are some procedures to follow to ensure the solar water heater works properly.

REFERENCE

1. M.Z.H. Khan, M.R.Al-Mamun, S.Sikdar, P.K. Halder, and M.R.Hasan, 2015. “Design, fabrication, and efficiency Study of a novel solar thermal water heating System: Towards sustainable development,” Inter. J. Photoenergy, Vol. 8, 2016.
2. O.A. Akintola, and A.Y. Sangodoyin, “Design development, and performance evaluation of solar heating system for disinfection of domestic Roof-Harvested rainwater,” Inter. Scho. Rese. Notices,vol.7, 2015.

3. Allouhi,A., et al., Solar domestic heating water systems in Morocco : An energy analysis. Energy Conversion and Management, 2015.92: p. 105-113.
4. Gastli, A. and Charabi, Y., Solar water heating initiative in Oman energy saving and carbon credits. Renewable & Sustainable Energy Reviews, 15, 1851-1856 (2011).
5. Michaelides, I.M. and Eleftheriou, P.C., An experimental investigation of the performance boundaries of a solar water heating system. Experimental Thermal & Fluid Science, 35, 1002-1009 (2011).
6. Pillai, I.R. and Banerjee, R., Methodology for estimation of potential for solar water heating in a target area. Solar Energy, 81, 162-172 (2007).
7. Bojić, M., Kalogirou, S. and Petronijević, K., Simulation of a solar domestic water heating system using a time marching model. Renewable Energy: An Inter. J., 27, 441-453 (2002).
8. Jaisankar, S., Ananth, J., Thulasi, S., Jayasuthakar, S.T. and Sheeba, K.N., A comprehensive review on solar water heaters. Renewable & Sustainable Energy Reviews, 15, 3045-3050 (2011)
9. O. A. Akintola, A. Y. Sangodoyin, and O. S. Adebayo, "Microbiological qualities of domestic roof-harvested rainwater in selected locations in Nigeria," Journal of Biological and Chemical Research, vol. 30, no. 2, pp. 849–860, 2013.
10. N. V. Ogueke, E. E. Anyanwu, and O. V. Ekechukwu, A review of solar water heating systems, Journal of Renewable and Sustainable Energy, 1 (2009), 043106.
11. Hasan, A. (1997). Thermosyphon solar water heaters: Effect of storage tank volume and configuration on efficiency. Energy Conversion and Management, 38(9), 847–854. https://doi.org/10.1016/S0196-8904(96)00099-4
12. Zeghib, I., & Chaker, A. (2011). Simulation of a solar domestic water heating system. Energy Procedia, 6, 292–301. https://doi.org/10.1016/j.egypro.2011.05.033
13. InterAction Council, The Global Water Crisis: Addressing an Urgent Security Issue, Papers for the InterAction Council, 2011- 2012, Series Editor: T. S.Axworthy, edited by H. Bigas, T.Morris, B. Sandford and Z. Adeel, 2012.
14. WHO, Guidelines for Drinking Water Quality. Volume 1: Recommendations, World Health Organization, Geneva, Switzerland, 3rd edition, 2008, http://www.who.int/water sanitation health/dwq/fulltext.pdf.
15. K. Gairaa and Y. Bakelli, "Solar energy potential assessment in the Algerian south area: case of Gharda¨ıa region," Journal of Renewable Energy, vol. 2013, Article ID 496348, 11 pages, 2013.
16. D. A. Hagos, A. Gebremedhin, and B. Zethraeus, "Solar water heating as a potential source for inland Norway energy mix," Journal of Renewable Energy, vol. 2014, Article ID 968320, 11 pages, 2014.
17. D. A. G. Redpath, Thermosyphon heat-pipe evacuated tube solar water heaters for northern maritime climates, Solar Energy, 86 (2012), 705–715.
18. Alternative Energy Tutorials. (2015). Solar Flat Plate Collectors for Solar Hot Water.http://www.alternative-energy-tutorials.com/solar-hot-water/flat-plate-collector.html