To Study the Working Principle of Solar Water Heater

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Abstract - Solar water heaters -- also called solar domestic hot water systems -- can be a cost-effective way to generate hot water for your home. They can be used in any climate, and the fuel they use – sunshine is free. Energy in the form of heat is required for diverse applications in various sectors including domestic, agricultural, commercial and industrial sectors. As there is a gap between demand and supply of thermal energy, it is essential not only to design and fabricate novel evacuated tubular systems but also to evaluate the thermal performance of existing evacuated tubular systems so as to match the demand and supply of heat energy. In this connection, the present investigation was carried out with specific objectives in connection with design, development and experimental evaluation of the thermal performance of the evacuated tube assisted systems for the design and fabrication of the solar water heater to use unconventional energy as a means to obtained hot water for domestic applications, at comparatively low cost and high capacity by the use of material like plastic lateral tubes, HDPE pipe, old glasswool, thermocol, plastic drum , G.I. sheet collect or boxes. India is blessed with solar energy in abundance at no cost. Solar water heating systems has been widely used in various industrial applications. *Solar water heating* collectors capture and retain heat from the sun and transfer this heat to a liquid. Solar water heating (SWH) is the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't.

IMAGES OF SOLAR WATER HEATER


INTRODUCTION

- The system basically consists of a collector, a tank, and thermosyphon system, very simple, not expensive, yet quiet efficient
- We have to do solar site survey to embark on any solar projects, this will ensure that you actually get enough sun on your collector to make it worthwhile
- Because temperature variation within the Solar Water Heater is not uniform, we have to measure water temperature at least in three strategic locations within the water heater.
- The temperature measurements within the heater are taken at the inlet, center and the outlet of the heater.
- This helps us visualize the temperature stratification within the heater.
- Furthermore, heat losses vary with ambient air temperature, which we consequentially included as a fourth measurement.
- Temperature measurements were taken with Onset temperature sensors

Active Solar Water Heating Systems

There are two types of active solar water heating systems:

Direct circulation systems

Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

Indirect circulation systems

Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.

Passive Solar Water Heating Systems

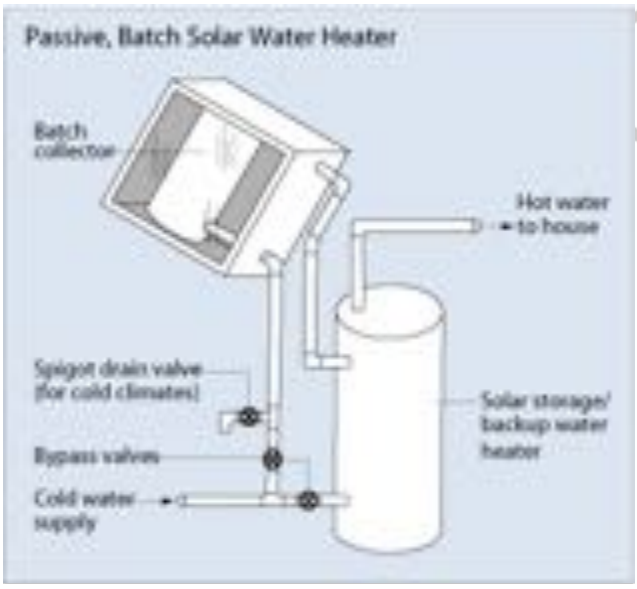
Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer.
There are two basic types of passive systems:

Integral Collector-Storage Passive Systems

These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.

Thermosyphon Systems

Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.



STORAGE TANKS AND SOLAR COLLECTORS

- A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water
- The total system with solar collector, storage tank and pipelines is called solar hot water system
- The solar water heating systems are of two types – closed loop system & open loop system
- In closed loop system, heat exchangers are installed to protect the system from hard water obtained from bore wells or freezing temperatures in cold regions
- The open loop system has two categories – thermosyphon & forced circulation system
- Thermo siphon systems are simple and relatively inexpensive
- The forced circulation systems employ electrical pumps to circulate the water through collectors and storage tanks

- The choice of system depends on heat requirement, weather conditions, , heat transfer fluid quality, space availability, annual solar radiation
- Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Three types of solar collectors are used for residential applications:

1. **Flat-Plate Collector**
   Glazed flat-plate collectors are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers. Unglazed flat-plate collectors -- typically used for solar pool heating have a dark absorber plate, made of metal or polymer, without a cover or enclosure.

2. **Integral Collector-Storage Systems**
   Also known as ICS or *batch* systems, they feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

3. **Evacuated-tube solar collectors**
   They feature parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss. These collectors are used more frequently for U.S. commercial applications.

SELECTING A SOLAR WATER HEATER

Before we purchase and install a solar water heating system, we want to do the following:

- Estimate the cost efficiency and energy efficiency of a solar water heating system
- Also understand the various components needed for solar water heating systems, including the following:
- Heat exchangers for solar water heating systems
- Heat-transfer fluids for solar water heating systems

Design of Solar Water Heater

The solar water heater is designed for "The supply of hot water to the bathroom sections and wash basins for a hotel in Hyderabad that I researched, so for this purpose a low cost water heating with heat storage system is being designed as follows.

To Design a Solar Water Heating System. For the purpose of designing we make following assumptions:
1) Daily water consumption : 300 liters /day
2)Water inlet temp = 35^oC
3)Since water is required for general purpose we have to design the water heater on following parameter.
i.e. a) Ambient temp = 25^oC &
b) Inclinations of collector = { altitude of place $+15^o$}
$=21^o +15$
$=36^o$
4)Wind Speed = 2 m/s
5)Fluid to tube heat transfer coeff. = 205 $W/m^2 C$

- We take following design parameter for the flat plate collector for Indian std
- Length of Solar Flat Plate Collector = 2.15m
- Width of Collector = 1.03m
- Length of absorber plate = 2.06m
- Width of Absorber Plate = 2.0m
- Plate to cover Spacing = 3cm

Design of Storage Tank

Since the capacity of tank required is 500 lit / day we know , specific vol of water
1 /1000 m^3/kg
$\therefore$ Capacity of storage tank = 500/1000 $=0.5m^3$
We design cylindrical shaped storage tank
Let D= dia of storage tank & L= Length of storage tank
Let L= 2.0 D

∴ Volume of storage tank = cross sectional area x length
$V = \pi/4.D^2L = \pi D^2 * 2D/4 = \pi D^3/4$
Let,
∴ Dia of cylinder tank = 0.74 m, & length of cylinder tank = 1.48 m.
Volume of Cylinder = 0.32 m^3

Cost Estimation of Solar Water Heater

The various parts, their charges (cost charge for assembling the project and other accessories are listed below :
1) G.I. collector box:- There are two collector boxes made of G.I. sheet of dimension 2.12m x 1.03 x 0.15 m has cost approx. Rs. 3000.
2) Plastic Dum:- The plastic drum has capacity of 300 lit and it cost approx. 800
3) G.I. Drum & cover :-A G.I.outer drum of 0.66 m diameter and its cover and its cost approx. Rs. 4514.
4) G.I. Sheet:- A G.I. Sheet of 14 x 3.5 x 0.40 Feet dimension and it costs approx. Rs. 700.
5) Glass:- Two glasses of Size 2.06 x 0.99 m x 0.005m and it cost approx. Rs. 2500.
6) Plastic lateral pipe/ tubes :- A Plastic lateral pipe of 12 mm outer diameter and 57 m is used and it cost approx. Rs. 310.
7) HDPE Pipe :- A HDPE pipe of 32 mm x 8 kg pressure of 10 metre is used and is cost approx. Rs. 1000.
8) Ki –tech heat resistant pipe and connectors :- IT a 6 mtre piece of 0.5" dia with connector and it cost approx. Rs.780.
9) Thermocol sheet :-Cost of thermocol sheet is Rs. 22/ sheet ,therefore total 16 kg cost 25 x 22 = approx. Rs.550 .
10) Glass – Wool :- Glass wool cost 20 Rs. /Kg ;therefore total 16 kg cost 25 x 20 = approx. Rs. 500. .
11) Total Hardware and general fitting expences :- The total Hardware and general: Fitting expences are Rs. 2000.
12) Matt Black paint:- Total Paint cost approx. Rs. 300.
13) Collector M.S. stands:- Each stand charge Rs. 1250. ∴No of collector =2
Total cost = 1250 x 2 = approx. Rs. 2500.
14) Hot water storage tank stand :- The total cost of stand = approx. Rs. 1500.
15) Total labour charges:- Labour charges for general fitting = approx.Rs. 1100.
Therefore total cost required for our solar water heater is approx. **Rs 22,054**/-
Hence low cost solar water heaters are selected for domestic, commercial and industrial and agricultural applications.

INSTALLING AND MAINTAINING THE SYSTEM

The proper installation of solar water heaters depends on many factors. These factors include solar resource, climate, local building code requirements, and safety issues; therefore, it's best to have a qualified solar thermal systems contractor install your system.

After installation, properly maintaining your system will keep it running smoothly. Passive systems don't require much maintenance. For active systems, discuss the maintenance requirements with your system provider, and consult the system's owner's manual. Glazing may need to be cleaned in dry climates where rainwater doesn't provide a natural rinse.

Regular maintenance on simple systems can be as infrequent as every 3–5 years, preferably by a solar contractor. Systems with electrical components usually require a replacement part or two after 10 years. When screening potential contractors for installation and/or maintenance, ask the following questions:

1. ***Does your company have experience installing and maintaining solar water heating systems?***
   Choose a company that has experience installing the type of system you want and servicing the applications you select.
2. ***How many years of experience does your company have with solar heating installation and maintenance?***
   The more experience the better. Request a list of past customers who can provide references.
3. ***Is your company licensed or certified?***
   Having a valid plumber's and/or solar contractor's license is required in some states. Contact your city and county for more information. Confirm licensing with your state's contractor licensing board. The licensing board can also tell you about any complaints against state-licensed contractors.

Improving Energy Efficiency

1. After your water heater is properly installed and maintained, try some additional energy-saving strategies to help lower your water heating bills, especially if you require a back-up system. Some energy-saving devices and systems are more cost-effective to install with the water heater.
2. The variables include the cost of installing the solar water heater and its life time, the rate of interest on the loan, the increase in electricity tariff and the type of electrical water heater.

APPLICATIONS OF SOLAR WATER HEATER

1) Domestic : Flats, Bungalows and Apartments, Car Wash,
2) Commercial : Hotels, Hospitals, Hostels and Dormitories, Restaurants,
3) Industrial : Process Industries, Preheating boiler feed water, Breweries & Wineries

- In domestic sector, hot water is used for bathing, washing of clothes & utensils etc.
- The requirement may, however, vary with the season of the year & number of family members.
- Our experience says that on an average 30 to 35 litres of water at 50 to 55º C. is consumed by an individual.
- Thus for a family of 4 members, 125 LPD Solar Water Heating System is quite sufficient.
- Depending on the distribution pattern of hot water, the system could be either modular or a big capacity single tank system.

CONCLUSIONS & RECOMMENDATIONS

1. Money of 20,000 rupees to 22,000 rupees investment cost is required to install Solar Water Heating system in existing homes at large market scale
2. Maintain conventional Solar Water Heating systems for 35%–40% source energy savings over conventional natural gas Water Heaters in cold climates
3. 15–25 year product lifetime with high system and component reliability and performance.
4. Nano coating on reflectors may be applied so as to increase the reflectance and hence the thermal performance of the solar heating and cooling systems.
5. Evacuate tubes with nano coatings (with maximum absorptance and minimum reflectance) may be utilized so as to augment the thermal performance of solar heating and cooling system.
6. Nano coating on evacuated tubes may be applied so as to reduce the reflectance and hence increase the thermal performance of solar heating and cooling systems
7. By materialising these researches, the thermal characteristics and performances of evacuated tubes, evacuated tube based solar fluid (water and air) heating system and evacuated tube based solar cooling system can be further increased favourably.
8. As a consequence, these solar thermal gadgets shall be effectively utilised energy-intensive sectors so as to reap the benefits like effective renewable energy utilization, effectual environment protection and economic development.

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