Experimental Investigation of Flat Plate and V-Trough Solar Water Heater by using Thermal Analysis

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Abstract

There are various types of solar water heating systems available in the commercial market to fulfill different customer's demand, such as flat plate collector, concentrating collector, evacuated tube collector and integrated collector storage. A cost effective cum easy fabricated V-trough solar water heater system using forced circulation system is proposed. Reason behind the selection of v-trough is that it is not only economical but also heat transfer rate is increased by positioning the glass plate at angle of 60degree. And also base plate collector maintaining maximum absorptivity due to given black coating. The radiation which incident on the V-trough are reflected back inside the entire setup and makes less radiation losses. Integrating the solar absorber with the easily fabricated V-trough reflector can improve the performance of solar water heater system. In this paper, optical analysis along with experimental study and cost analysis of the stationary V-trough solar water heater system are presented in details. The experimental result has shown very promising results in both optical efficiency of V-trough reflector and the overall thermal performance of the solar water heater.

Keywords: V-Trough Collector, Solar Water Heater, Circulation System, Solar Collector, Solar Absorber

I. INTRODUCTION

This project work provides basic information on the components and types of solar water heaters currently available and the economic and environmental benefits of owning a system. Solar water heaters, sometimes called solar domestic hot water systems, are cost competitive in many applications when you account for the total energy costs over the life of the system. Although the initial cost of solar water heaters is higher than that of conventional water heaters, the fuel (sunshine) is free. Plus, they are environmentally friendly.

These systems use the sun to heat either water or a heat-transfer fluid, such as a water-glycol antifreeze mixture, in collectors. The heated water is then stored in a tank similar to a conventional gas or electric water tank. Some systems use an electric pump to circulate the fluid through the collectors. Solar water heaters can operate in any climate. Performance varies depending, in part, on how much solar energy is available at the site, but also on how cold the water coming into the system is. The colder the water, the more efficiently the system operates.

A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the heat to the riser pipes underneath the absorber panel. The water passing through the riser gets heated up and is delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature of the water. The total system with solar collector, storage tank and pipelines is called solar hot water system.

II. PROBLEM DEFINITION

Now at present the horizontal solar water heater setups are gives some satisfaction level of Heat transfer Performance , Again it has chances to improve the heat transfer performance by conducting further more research work by means of Design and reconstruction, Operating technique, also material selection. Which may influences better results in heat transfer and performance improvement.

III. ENERGY

Energy is the capacity to do work. Energy comes in various forms, such as motion, heat, light, electrical, chemical, nuclear energy, and gravitational. Total energy is the sum of all forms of the energy a system possesses. In the absence of magnetic, electrical and surface tension effects, the total energy of a system consists of the kinetic, potential, and internal energies. The internal energy of a system is made up of sensible, latent, chemical, and nuclear energies. The sensible internal energy is due to translational, rotational, and vibration effects of atoms and molecules.

A. Various Forms of Energy

There are two types of energy - stored (potential) energy and working (kinetic) energy. For example, the food we eat contains chemical energy.

- Kinetic Energy

B. Heat transfer

Heat is defined in physics as the transfer of thermal energy across a well-defined boundary around a thermodynamic system. It is a characteristic of a process and is never contained in matter. The term heat transfer has acquired a specific usage, despite its literal redundancy of the characterization of transfer. In these contexts, heat is taken as synonymous to thermal energy.

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy and heat between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. Engineers also consider the transfer of mass of differing chemical species, either cold or hot; to achieve heat transfer. Fundamental methods of heat transfer in engineering include conduction, convection, and radiation.

C. Methods of Heat Transfer

There are three major methods of heat transfer

- Conduction
- Convection
- Radiation.

IV. CONSTRUCTIONAL DETAILS

In a "close-coupled" SWH system the storage tank is horizontally mounted immediately above the solar collectors on the roof. No pumping is required as the hot water naturally rises into the tank

Through thermosyphon flow In a "pump-circulated" system the storage tank is ground or floor-mounted and is below the level of the collectors; a circulating pump moves water or heat transfer fluid between the tank and the collectors.

These systems can be classified into three main categories:

- Active systems
- Passive systems
- Batch systems

In the thermosyphon system, water comes from the overhead tank to bottom of solar collector by natural circulation and water circulates from the collector to storage tank as long as the absorber keeps absorbing heat from the sun and water gets heated in the collector.

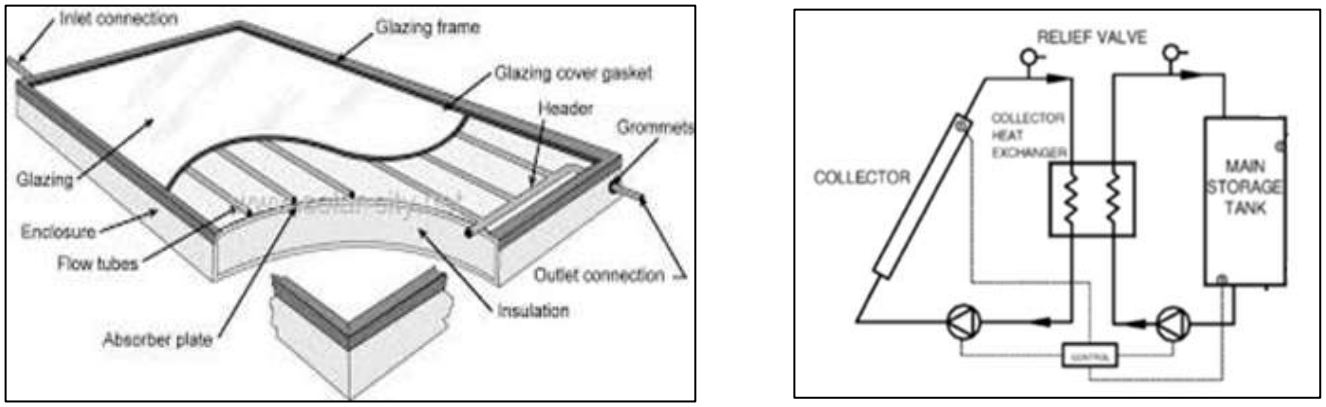

Fig. 1: Flat Plate Collectors

The cold water at the bottom of storage tank run into the collector and replaces the hot water, which is then forced inside the insulated hot water storage tank.

The process of the circulation stops when there is no solar radiation on the collector. Thermosyphon system is simple and requires less maintenance due to absence of controls and instrumentation. Efficiency of a collector depends on the difference between collector temperature and ambient temperature and inversely proportional to the intensity of solar radiation.SWH generally consists of a solar radiation collector panel, a storage tank, a pump, a heat exchanger, piping units, and auxiliary heating unit. Collector, concentrated solar collector Flat-plate collectors are used extensively for domestic water heating applications. It is simple in design and has no moving parts so requires little maintenance.

It is an insulated, weatherproofed box containing a dark absorber plate under one or more transparent covers. Evacuated-Tube Collectors are made up of rows of parallel, transparent glass tubes. Each tube consists of a glass outer tube and an inner tube, or absorber, covered with a selective coating that absorbs solar energy well but inhibits radioactive heat loss. The air is withdrawn ("evacuated") from the space between the tubes to form a vacuum, which eliminates conductive and convective heat loss.

Concentrating collectors use mirrored surfaces to concentrate the sun's energy on an absorber called a receiver. A heat-transfer fluid flows through the receiver and absorbs heat. These collectors reach much higher temperatures than flat-plate collectors and evacuated-tube collectors, but they can do so only when direct sunlight is available.

Most commercially available solar water heaters require a well insulated storage tank. Thermal storage tank is made of high pressure resisted stainless steel covered with the insulated fiber and aluminum foil.

A heat transfer fluid is used to collect the heat from collector and transfer to the storage tank either directly or with the help of heat exchanger. In order to have an efficient SHW configuration, the fluid should have high specific heat capacity, high thermal conductivity, and low viscosity.

And low thermal expansion coefficient, anti-corrosive property and above all low cost. Among the common heat transfer fluids such as water, glycol, silicon oils and hydrocarbon oils, the water turns out to be the best among the fluids.

D. Types of Solar Collectors

When solar radiation passes through a transparent cover and impinges on the blackened absorber surface of high absorptive, a large portion of this energy is absorbed by the plate and then transferred to the transport medium in the fluid tubes to be carried away for storage or use. The underside of the absorber plate and the side of casing are well insulated to reduce conduction losses. The liquid tubes can be welded to the absorbing plate, or they can be an integral part of the plate. The liquid tubes are connected at both ends by large diameter header tubes.

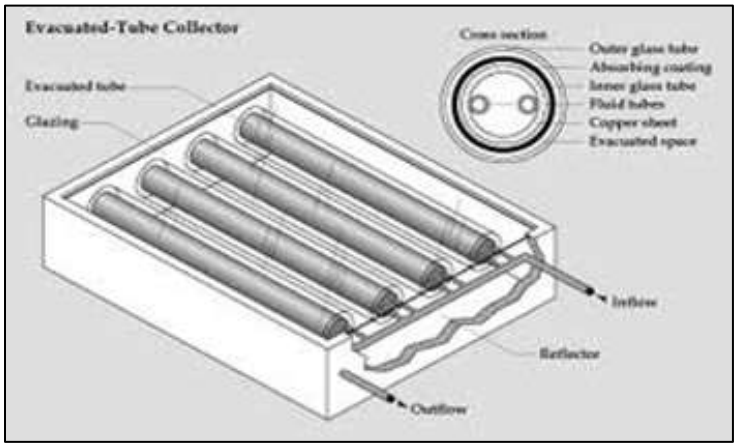

Fig. 2: Evacuated tube collector

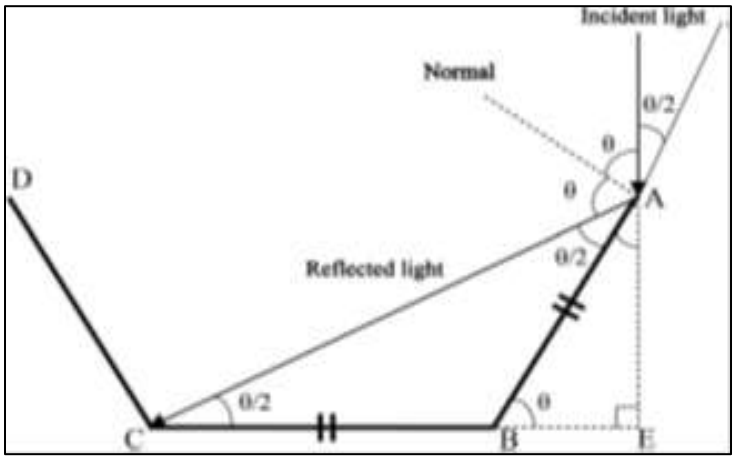

Fig. 3: V-Trough Collectors

The transparent cover is used to reduce convection losses from the absorber plate through the restraint of the stagnant air layer between the absorber plate and the glass. It also reduces radiation losses from the collector as the glass is transparent to the short wave radiation received by the sun.

It is nearly opaque to long-wave thermal radiation emitted by the absorber plate.PTCs are made by bending a sheet of reflective material into a parabolic shape. A metal black tube, covered with a glass tube to reduce heat losses, is placed along the focal line of the receiver.

Glass has been widely used to glaze solar collectors because it can transmit as much as 90% of the incoming shortwave solar irradiation while transmitting virtually none of the long wave radiation emitted outward by the absorber plate. Glass with low iron content has a relatively high transmittance for solar radiation (approximately 0.85-0.90 at normal incidence), but its transmittance is essentially zero for the long wave thermal radiation (5.0-50 mm) emitted by sun-heated surfaces.

Plastic films and sheets also possess high shortwave transmittance, but because most usable varieties also have transmission bands in the middle of the thermal radiation spectrum, they may have long wave transmittances as high as 0.40. Plastics are also generally limited in the temperatures they can sustain without deteriorating or undergoing dimensional changes.

V. EXPERIMENTAL SETUP

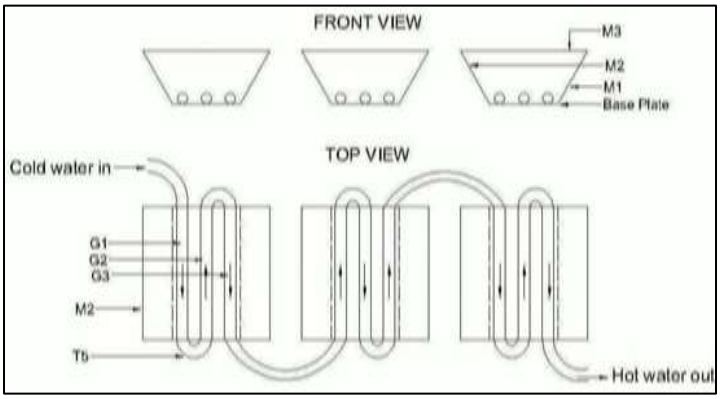

Fig. 4: V Trough Collector

- Type of reflector back - Coated float glass mirror
- Total number of mirrors Per V- Trough reflector
- Inclined angle of each mirror
- Total reflective area of each V- Trough collector
- Dimension of each absorber plate
- Total sets of V- Trough collector
- Total mass of water in the storage tank

VI. SOLUTION METHODOLOGY

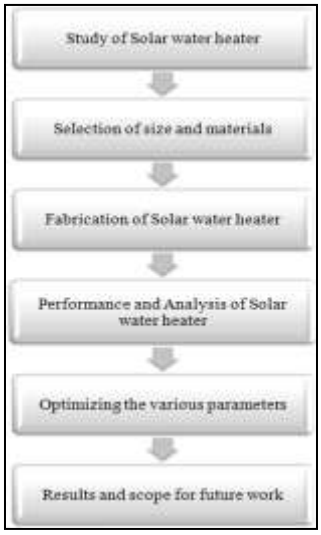

Fig. 5: Methodology Flow Chart

VII. RESULT AND DISCUSSION

Fig 7 Take X-Axis in Hours and Y-Axis in Temperature.

S.NO	INDIAN TIME	TOTAL HOURS	FLAT PLATE COLLECTOR TEMP IN ^{0}C	V TROUGH COLLECTOR TEMP IN ^{0}C
1	10 AM	5	33	39
2	11 AM	6	35	59.5
3	12 PM	7	39	79
4	01 PM	8	41.5	88
5	02 PM	9	42.5	86
6	03 PM	10	41	82
7	04 PM	11	36.5	76
8	05 PM	12	33	72

Fig. 6: Comparison of flat plate collector and V through collector

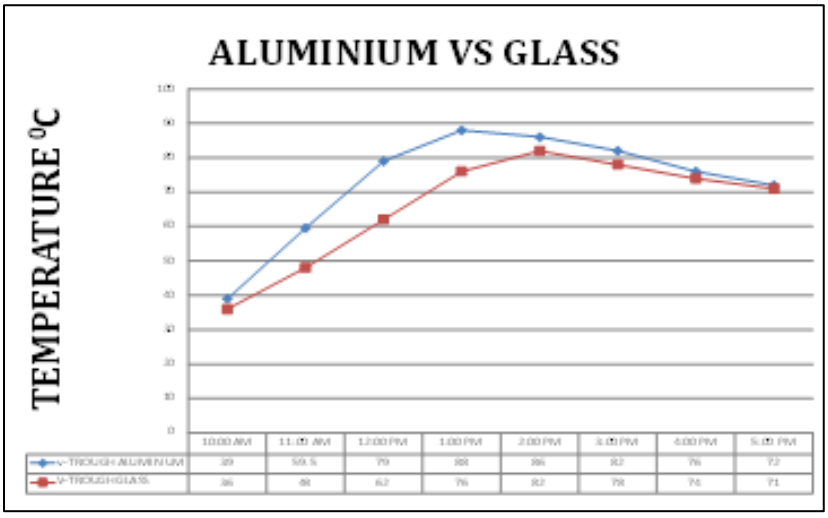

Fig. 7: Take X axis in hours and y axis in temperature

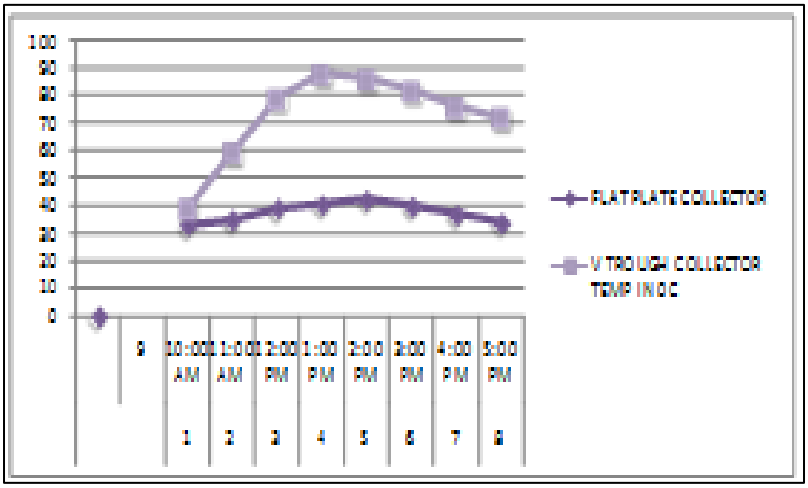

Fig. 8: Comparison of flat plate collector and V through collector

Fig. 9: Experimental Setup

Above the graph initial temperature, middle temperature and final thermal storage temperature discussed. In comparison of flat plate collector and V Trough collector the more heat transfer, maximum absorbtiity, temperature rise and thermal storage level increased.

VIII. CONCLUSION

Based on the above analysis, solar water heating system is the most inexpensive type heater in use. By considering cost to benefit hierarchies, the solar water heating system produces the most inexpensive but more convincing results. The various type of solar collectors described includes flat plate, compound parabolic and evacuated type.

In the further work, will planned to construct a V-type collector with enhancement in following parameters,

- Incident radiation
- Heat transfer rate
- Thermal analysis parameters

REFERENCES

[1] K.K. Chong K.G. Chay "Study of a solar water heater using stationary V-trough collector "Journal of Elsevier, Volume 39 2011, P 207-215.
[2] FuadMammadov "Study of Selective Surface of Solar Heat Receiver" Journal of International Journal of Energy Engineering, Volume 2 2012, P 138-144.
[3] Basil Okafor "Thermo Siphon Solar Water Heater " Journal Of International Journal of Energy Engineering , Volume 3 March-2013, P 313-316.
[4] Anupamaa S Chavan, Dr. Madhav N Welling "Assessing the Awareness of Government Subsidy for Solar Water Heaters among People " Journal Of American International Journal of Research in Humanities, Arts and Social Sciences 2, Volume May-2013, P 154-161.
[5] Kishan Patel Pragna Patel, AndJatin Patel "Review Of Solar Water Heating Systems" Journal Of International Journal of Advanced Engineering Technology, Volume 3Dec-2012, P 146-149.
[6] Ibrahim Ladan Mohammed "Study of an efficient compact solar water heater "Journal Of International Journal of Engineering Research and Applications (IJERA),Volume 2 Feb-2012, P 822-830.
[7] DharamvirMangal, Devander Kumar Lamba "Acknowledgement Of Evacuated Tube Solar Water Heater Over Flat Plate Solar Water Heater" Journal Of International Journal of Engineering (IJE) , Volume 4 2009, P 279-284.
[8] Eze J. I and OjikeO"Analysis of thermal efficiency of a passive solar water heater"JournalOf International Journal of Physical Sciences, Volume 7 June-2012, P 2891-2896.
[9] G. C. Nalamwar, N. R. Kannake, S. S. Sontakke "Study and Fabrication of Vacuum Tube Collector Solar Water Heater "International Journal of Engineering and Innovative Technology (IJEIT), Volume 2 July-2012, P 220-224.
[10] Pankaj Kumar MongreBhupendra Gupta "Experiment study of solar water heater with circulating pump and using of Aluminum tube" Journal Of International Journal of Engineering Trends and Technology, Volume 4 2013,P 384-391.
[11] Shahidul Islam Khan, Asif Islam "Performance Analysis of Solar Water Heater " Journal Of Smart Grid and Renewable Energy , Volume 2 No-2011, P 396-398.
[12] Audrey Dobbins LudgerEltrop "Economic and environmental analysis of solar heater utilization in Gauteng Province, SouthAfrica" Journal of Institute of Energy Economics and the Rational Use of Energy, volume 23 May-2012, P 2-19.