REVIEW OF RENEWABLE ENERGY THE SOLAR WATER HEATER SYSTEM

Jhanbux Manek Variava[1], Ayushi Sanjaybhai Bhavsar[2]

Master Engineering, Mechanical Engineering, MGITER, Navsari (GTU) India
Bachelor Engineering, Mechanical Engineering, MGITER, Navsari (GTU) India

ABSTRACT

Solar water Heater (SWH) is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations are available at varying cost to provide solutions in different climates and latitudes. SWHs are widely used for residential and some industrial application. As the Solar water heating systems have a widespread usage and applications in both domestic and industrial sectors. Solar water heating is not only environmentally friendly but requires minimal maintenance and operation cost compared to other solar energy applications. SWH systems are cost effective with an attractive payback period of 2–4 years depending on the type and size of the system. Extensive research has been performed to further improve the thermal efficiency of solar water heating. This paper presents a detailed review exclusively on the design aspects of SWH systems.

Keyword: - *Active system, Passive system, Flat plat, Collectors, Glycol, Glass wool*

1 INTRODUCTION

We are blessed with Solar Energy in abundance at no cost. The solar radiation incident on the surface of the earth can be conveniently utilized for the benefit of human society. One of the popular devices that harness the solar energy is solar hot water system (SHWS).

The solar energy is the most capable of the alternative energy sources. Due to increasing Demand for energy and rising cost of fossil type fuels (i.e., gas or oil) solar energy is considered an attractive source of renewable energy that can be used for water hearing in both homes and industry. Heating water consumes nearly 20% of total energy consumption for an average family. Solar water heating systems are the cheapest and most easily affordable clean energy available to homeowners that may provide most of hot water required by a family.

Solar heater is a device which is used for heating the water, for producing the steam for domestic and industrial purposes by utilizing the solar energy. Solar energy is the energy which is coming from sun in the form of solar radiations in infinite amount, when these solar radiations falls on absorbing surface, then they gets converted into the heat, this heat is used for heating the water. This type of thermal collector suffers from heat losses due to radiation and convection. Such losses increase rapidly as the temperature of the working fluid increases.

2 SOLAR WATER HEATING SYSTEM

Solar water heating systems harness solar and, in some cases, are supplemented by ambient energy to heat water. The first commercial SWH, named Climax was patented in the US by Kemp. In the early1900s, several researchers focused their attention to improving the design of the SWH systems to make them durable and efficient. SWH systems were commercialized on a wider scale in the early1960s.In the sections below, a variety of SWH systems are reviewed and classified in terms of circulation methods and applications, with a discussion on the designs and modifications in recent years [1]. These systems can be broadly categorized as passive solar water heating systems and active solar water heating systems.

2.1 Active Systems

Active systems use electric pumps, valves, and controllers to circulate water or other heat-transfer fluids through the collectors. So, the Active systems are also called forced circulation systems and can be direct or indirect. The active system is further divided into two categories:

• Open-loop (Direct) Active System

• Closed-loop (Indirect) Active System

a) Open-Loop Active Systems

Open-loop active systems use pumps to circulate water through the collectors. This design is efficient and lowers operating costs but is not appropriate if the water is hard or acidic because scale and corrosion quickly disable the system. These open-loop systems are popular in non-freezing climates.

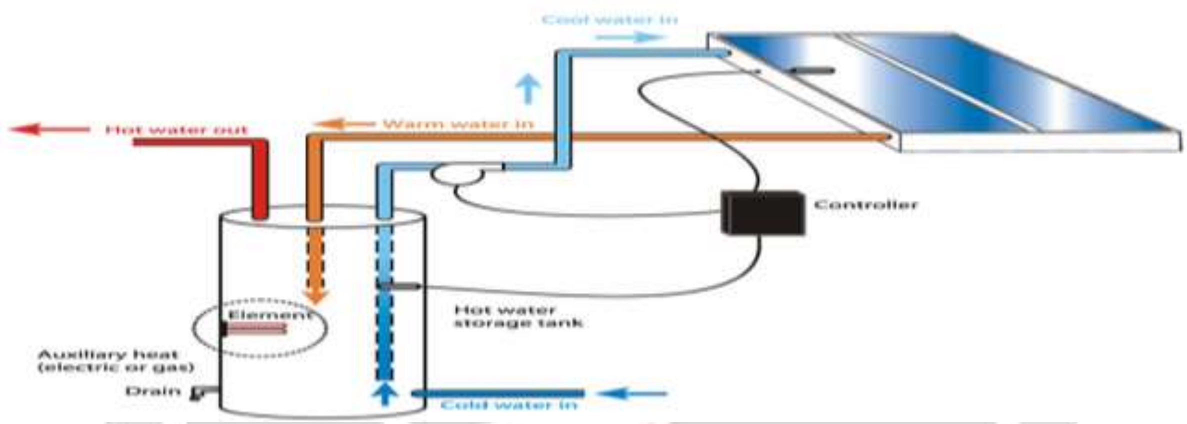

Fig- 1: Open-Loop Active Systems

b) Closed-loop (Indirect) Active System

These systems pump heat-transfer fluids (usually a glycol-water antifreeze mixture) through collectors. Heat exchangers transfer the heat from the fluid to the household water stored in the tanks. Closed-loop glycol systems are popular in areas subject to extended freezing temperatures because they offer good freeze protection.

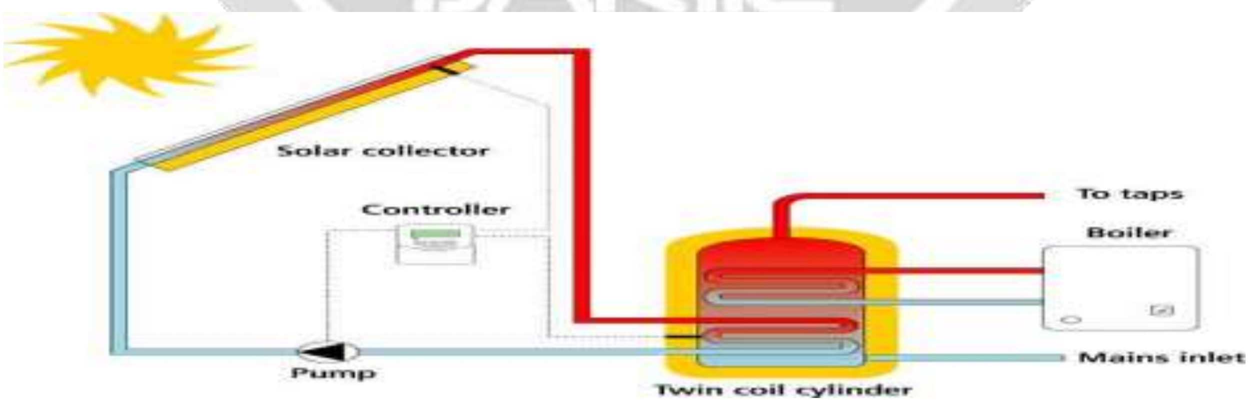

Fig- 2: Closed-Loop Active Systems

An integrated collector storage (ICS or Batch Heater) system uses a tank that acts as both storage and collector. Batch heaters are thin rectilinear tanks with a glass side facing the sun at noon. They are simple and less costly than plate and tube collectors, but they may require bracing if installed on a roof (to support 400–700 pounds (180–

320 kg) lbs of water), suffer from significant heat loss at night since the side facing the sun is largely uninsulated and are only suitable in moderate climates.

A convection heat storage unit (CHS) system is similar to an ICS system, except the storage tank and collector are physically separated and transfer between the two is driven by convection. CHS systems typically use standard flat-plate type or evacuated tube collectors. The storage tank must be located above the collectors for convection to work properly. The main benefit of CHS systems over ICS systems is that heat loss is largely avoided since the storage tank can be fully insulated. Since the panels are located below the storage tank, heat loss does not cause convection, as the cold water stays at the lowest part of the system.

2.2 Thermosiphon Systems

In the thermosiphon system, water comes from the over head 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. 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. Thermosiphon 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.

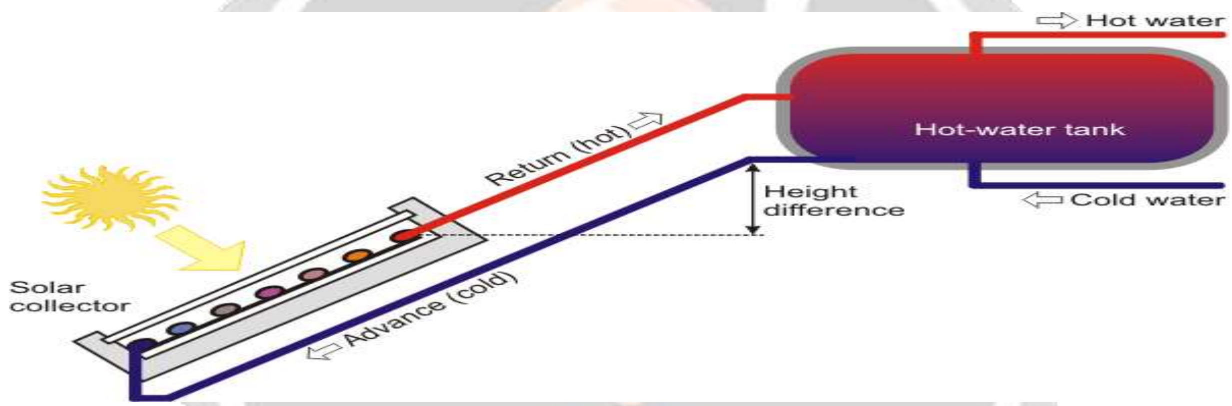

Fig- 3: Thermosiphon Systems

2.3 Batch Systems

Batch System (also known as integral collector storage systems) are simple passive systems consisting of one or more storage tanks placed in an insulated box that has a glazed side facing the sun. Batch systems have combined collection and storage functions. Depending on the system, there is no requirement for pumps or moving parts, so they are inexpensive and have few components in other words, less maintenance and fewer failures.

2.4 Solar Collectors

The choice of collector is determined by the heating requirements and the environmental conditions in which it is employed. There are mainly three types of solar collectors like flat plate solar collector, evacuated tube solar collector, concentrated solar collector.

a) Flat Plate Collectors

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. They collect both direct and diffuse radiation. Their simplicity in construction reduces initial cost and maintenance of the system. A more detailed picture of these systems is of interest and is presented in the following section.

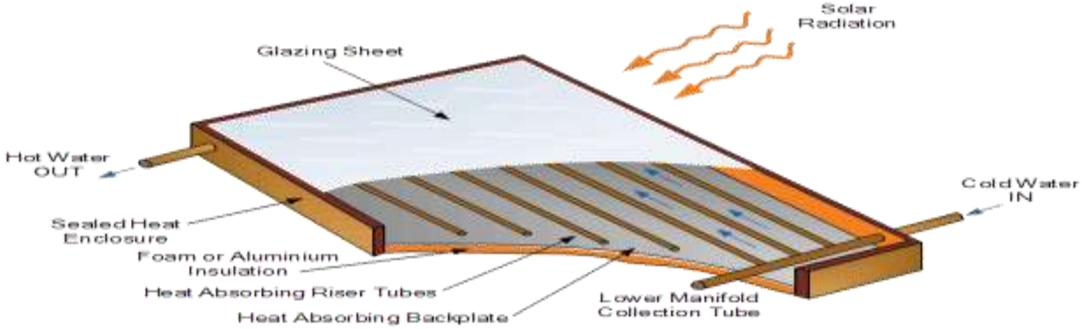

Fig- 4: Flat Plate Collector

b) Evacuated-Tube Collectors

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. They are most suited to extremely cold ambient temperatures or in situations of consistently low-light. They are also used in industrial applications, where high water temperatures or steam need to be generated where they become more cost effective

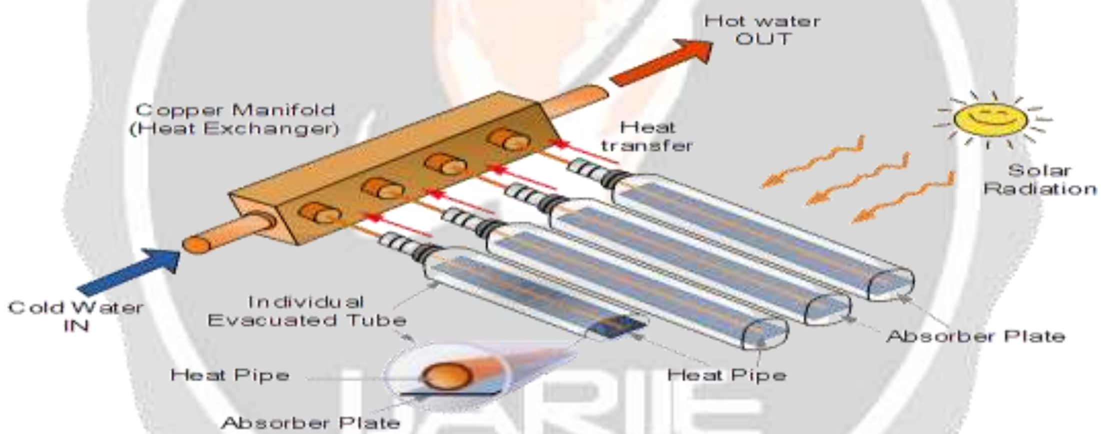

Fig- 5: Evacuated-Tube Collectors

c) Concentrating Collectors

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. However, concentrators can only focus direct solar radiation, with the result being that their performance is poor on hazy or cloudy

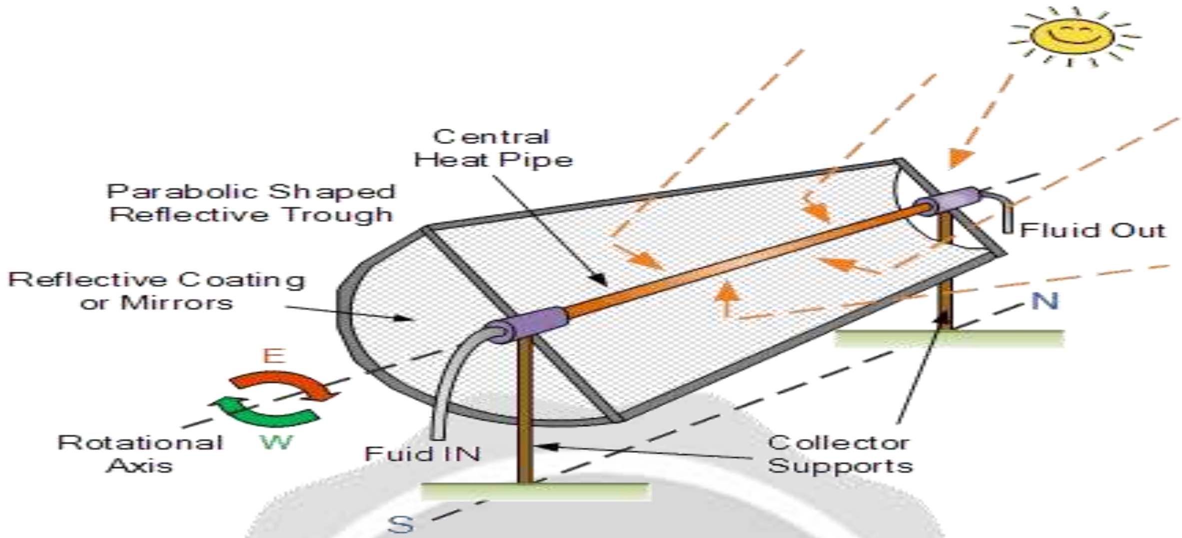

Fig- 6: Concentrating Collectors

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. Some solar water heaters use pumps to recirculation warm water from storage tanks through collectors and exposed piping. This is generally to protect the pipes from freezing when outside temperatures drop to freezing or below

2.5 Heat Transfer Fluid

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, 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. Water is the cheapest, most readily available and thermally efficient fluid but does freeze and can cause corrosion.

3 Literature Review

H.Y. andoh, et. al [1] In this research paper the thermal performance of the solar water heater designed with a local vegetable material as insulating material, coconut coir, widespread in tropical countries. The study focuses on the comparative thermal performance of this collector and another collector, identical in design, fabrication and operating under the same condition, using glass wool as heat insulation as well as with eight other design, chosen randomly using various materials as heat insulation with performance data from the literature, the material cost of the coconut coir collector is 25 % less than the glass wool one. The result of the study show very good thermal performance of the collector using coconut coir compared to the traditional ones.

Soteris A. Kalogirou et.al[2] presents a survey of the various types of solar thermal collectors and applications. All the solar systems which utilize the solar energy and its application depends upon the solar collector such as flat-plate, compound parabolic, evacuated tube, parabolic trough, Fresnel lens, parabolic dish and heliostat field collectors which are used in these system. The solar collectors are used for domestic, commercial and industrial purposes. These include solar water heating, which comprise thermosiphon, integrated collector storage, direct and indirect systems and air systems, space heating and cooling, which comprise, space heating and service hot water, air and water systems and heat pumps, refrigeration, industrial process heat, which comprise air and water systems and steam generation systems, desalination, thermal power systems, which comprise the parabolic trough, power tower and dish systems, solar furnaces, and chemistry applications.

Table- 1 Comparision of the Collectors [2]

Motion	Collector type	Absorber type	Concentration type	Temperature range(C^0)
Stationary	(FPC)	Flat	1	30-80
	(ETC)	Flat	1	50-200
	(CPC)	Tubular	1-5	60-240
Single-axis tracking	(LFR)	Tubular	15-45	60-250
	(PTC)	Tubular	15-45	60-300
	(CTC)	Tubular	10-50	60-300
Two-axes Tracking	(PDR)	Point	100-1000	100-500
	(HFC)	Point	100-1500	150-2000

Mustafa AKTAß et. al[3]describe experimental analysis of optimum fin size, which can be used in heat exchanger in solar energy systems, has been performed. For this purpose, two systems, one of which is classic and the other finned, were designed and manufactured. According to the experimental tests, which lasted for six days, the system with a fin is 7% more efficient than the classical system. Therefore, it has been concluded that it is useful to use fins in solar energy systems with a suitable sizing

Samara Sadrin et.al[4] present the alternative method of solar water heating system. This automated system would allow the user to get hot water from the solar water heater as long as the solar water heater can supply hot water above a set temperature. If the solar water heater is unable to supply water above the set temperature, then only will the electric water heater come into action. It is efficient because our controller ensures that the solar water heater is used to supply hot water 80% of the time, and the rest 20% will be supplied by the electric water heater. It is cheap because, our system runs on solar energy which is abundant and free. It uses very small amount of electricity and therefore, reduces the expenses for the user.

Sumitambade, et.al[5]this paper represents a simple method, low cost combined batch type solar water heater cum regenerative solar still. In this paper effort is being is made to integrate two different solar appliances so that they could work in much better way. Solar water heater cum distillation system is designed and fabricated to carry out two operations simultaneously heating of water and distillation. This composite unit performs more than one operation and converts solar energy into the thermal energy to make the devices more versatile and efficient.

R. Herreroet. et.al[6] describe enhancement techniques for flat-plate liquid solar collectors. Tube-side enhancement passive techniques can consist of adding additional devices which are incorporated into a smooth round tube (twisted tapes, wire coils), modifying the surface of a smooth tube (corrugated and dimpled tubes) or making special tube geometries (internally finned tubes). For the typical operating flow rates in flat-plate solar collectors, the most suitable technique is inserted devices. Based on previous studies from the authors, wire coils were selected for enhancing heat transfer. This type of inserted device provides better results in laminar, transitional and low turbulence fluid flow regimes.

K. Sivakumaret et.al[7] represent the design of Elliptical heat pipe flat plat solar collector and tested with a collector tilt angle of 11° to the horizontal. Experimental analysis of the effect of condenser length/evaporator length (Lc/Le) ratio of the heat pipe, different cooling water mass flow rates and different inlet cooling water temperature were analyzed. Five numbers of elliptical heat pipes with stainless steel wick has been fabricated and used as transport tubes in the collector. Copper tube has been used as container material with methanol as working fluid of the heat pipe. These heat pipes were fixed to the absorber plate of the solar collector and the performance of elliptical heat pipe solar collector has been studied and results were compared. It has been found from the experimental trials that the elliptical heat pipe solar collector having Lc/Le ratio of 0.1764 achieved higher instantaneous efficiency.

Wattana Ratismith et. Al[8] describes the design of the PTC in which increase the outlet temperature by reducing heat loss. In this design the maximum efficiency of the collector is 32% and has an ability to achieve high output temperature, the maximum temperature at header of evacuated tube is 235 degrees Celsius, and is therefore suitable for high temperature application such as industrial uses.

4. CONCLUSIONS

At Present, Solar water heating systems are installed with different configurations and arrangements. The basic technology concrete of these systems are studied and it is found that there is a need to work on the generated design procedure to select, install and monitor the solar water heating system as per the availability.

6. REFERENCES

[1]. H.Y. andoh, p. Ghaha, B.K. koua, P.M.E. koffi, S. Toure, Thermal performance study of a solar collector using a natural vegetable fiber, coconut coir, as heat insulation Energy for sustainable development 14 (2010) 297-301

[2]. Soteris A. Kalogirou, ―Solar thermal collectors and applications, Progress in Energy and Combustion Science 30 (2004) 231–295.

[3]. Mustafa AKTAß, OlhanCEYLAN,Hikmet DOĞAN ― The Thermal Effectiveness Compression Of The Classical And Finned Solar System‖ Isı BilimiveTekniğiDergisi, 26, 2, 29-33, 2006. J. of Thermal Science and Technology 2006 TIBTD Printed in Turkey ISSBN 1300-3615.

[4]. Samara Sadrin, Maherin Hossain, EhsanulMohith, ―Alternative solar water heater for domestic purpose‖.

[5]. Sumitambade, tarunnarekar, vikrantkatekar, Performance evaluation of combined batch type solar water heater cum regenerative solar still

[6]. R. Herrero Martín, A. García Pinar, J. Pérez García ―Experimental heat transfer research in enhanced flat-plate solar collectors, World Renewable Energy Congress -2011, Sweden.

[7]. K. Sivakumar, N. Krishna Mohan and B. Sivaraman ―Performance analysis of elliptical heat pipe solar collector Indian Journal of Science and Technology.

[8]. WattanaRatismith, ―A Novel Non-Tracking Solar Collector for High Temperature Application, proceedings of ecos 2012 - the 25th international conference on efficiency, cost, optimization, simulation and environmental impact of energy systems June 26-29, 2012, Perugia, Italy.