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A Review Paper on Solar Water Heater by Evacuated Tube

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Abstract -- *Solar water heater by evacuated tube uses evacuated tube solar collector which is more efficient than flat plate collector. In this evacuated tube copper heat pipe is filled with non-toxic liquid. As sun heats the liquid it vaporize and rise to the top of the heat pipe and it cause heating the water passing around it. This system has good thermal efficiency and low maintenance. Conductive and convective heat loss is very low in this system. Result of less heat loss is fast heating of water as compared to flat plate solar water heater etc.*

Keywords— *Solar, Water heater, Evacuated tube, etc.*

I. INTRODUCTION

Sun is the source of all energy on the earth. It is most universal source of energy. It is free of cost. It is also important of non-conventional source or energy because it is non-polluting India is blessed with sufficiently of solar energy because most parts of the country receive bright sunshine throughout the year but a brief monsoon period. India has developed technology to use solar energy for cooking, water heating, water dissimilation, space heating, crop drying etc.

Solar water heaters use the solar energy from the sun to generate heat which can be used to heat water for space heating ,Industrial processing or even solar cooling there are many types of solar collector can be used in solar water heater in which evacuated tube collector have very high efficiency and better performance.

Evacuated tube solar collectors are very efficient and can achieve very high temperatures. Evacuated tube solar collectors are well-suitable to commercial and industrial heating applications and can be an effective alternative to flat-plate collectors for domestic space heating especially in areas where it is often cloudy.

An evacuated-tube collector contains several rows of glass tubes connected to a header pipe. Each tube has the air removed from it (evacuated) to eliminate heat loss through convection and conduction. Inside the glass tube, a flat or curved aluminum or copper fin is attached to a metal pipe. The fin is covered with a selective coating that transfers heat to the fluid that is circulating through the pipe

II. LITERATURE REVIEW

M.V. Kulkarni, Dr. D. S Deshmukh (2014) [1] focused on PCM type solar water heater. The system consists of two simultaneously functioning heat-absorbing units. One of them is a solar water heater and the other a heat storage unit consisting of PCM (paraffin). The water heater functions normally and supplies hot water during the day. The storage unit stores the heat inPCMs during the day supplies hot water during the night.

Eze J. I. and Ojike O. (2012) [2] investigated the thermal efficiency of a passive solar water heater is undertaken. The solar water heater has two storage tanks and is used for cold and warm waters, respectively. Here copper pipes are placed in the spiral form only.

P.Selvakumar, Dr.P.Somasundaram (2012) [3] studied the effect of inclination of solar water heater on its thermal performance. The present study is carried out to find the temperature characteristics of the evacuated tube at tilt angles, viz. 0°, 15°, 30°, 45°, 60° and 90°. Obviously this idea of angles on the basis of application will create a greater impact on this environmental concerned world. The main reason why solar heaters are not preferred is the price and complexity. But when it is apparent that one can go on with any angles and less complexity which in turn means low pricing will increase the number of users to switch from electric water heaters to solar.

Figure 2. Mounting Stand [2]

Morrison et al (2004) [4] analyzed the water-in-glass evacuated tube. In his research findings he has mentioned that evacuated tube solar collectors perform better than flat plate collectors during high temperature operations. Water-in-glass tube collector seems to be a better option for domestic utilization because of its simplicity and low cost. The water-in-glass evacuated tubes are manufactured in large quantity in China and Europe. Many solar water heater manufacturers in India are importing the evacuated tubes from China. The market for solar water heaters with evacuated tube collector is growing swiftly because of low cost and better performance. The space required for mounting a 100 LPD solar water heater is 30m2 . In a multi-storied apartment, if the resident in the ground floor want to use solar water heater, he has to use the terrace of the building for mounting the collectors. The hot water has to travel through the long pipe line. The resident has to spend more money for plumbing works. Also, there will be a significant energy loss when the water travels through the long pipe. If the terrace is occupied for some other purpose like advertisement hoarding, television antenna, etc., it will be difficult for mounting the solar water heater. In order to avoid all those problems, it is essential to study the performance of the evacuated tube at various angles of inclination. If the performance remains same for all angles of inclination, it will be easy to mount the collectors. Runsheng Tang et al (2011) studied the thermal performance of water-in-glass evacuated tube solar water heaters with different collector tilt angles. The team conducted the experiment at two different angles 22° and 46°. There is no significant variation in daily thermal efficiency. But this study does not provide the data for other angles of inclination, particularly 0° and 90°. The present study is carried out to find the temperature characteristics of the evacuated tube at tilt angles, viz. 0°, 15°, 30°, 45°, 60° and 90°. Obviously this idea of angles on the basis of application will create a greater impact on this environmental concerned world. The main reason why solar heaters are not preferred is the price and complexity. But when it is apparent that one can go on with any angles and less complexity which in turn means low pricing will increase the number of users to switch from electric water heaters to solar. Literatures state that the collectors should face the south direction to receive sunlight for maximum period of time. This factor is also taken into consideration. The experiment is conducted with the tubes facing south direction as well as north direction. The results are interesting and they raise question on literatures' statement.

Eze J. I. and Ojike O. (2012) [5] The analysis of thermal efficiency of a passive solar water heater is presented. The heater which has potential applications in agro-industries and homes, consisted of a single-glazed flat plate solar collector made up of an absorber plate and a transparent sheet of glass; water storage tanks and the stand. The absorber plate was made of mild steel which is a very good conductor of heat. Copper tube was used to form a loop on the mild steel absorber. Water in the loop is heated by the radiant energy trapped by the absorber. The system was tested experimentally under daytime load conditions at Nsukka, Nigeria, over the ambient temperature range of 21 to 31°C, and a daily global irradiation range of 8.3 to 17.4 MJ m^{-2}. Peak temperature rise of the heated water was about 83°C, while the maximum daily average useful efficiency was about 42%. It was deduced that the system can be operated successfully for agro-industries and home applications.

M.V. Kulkarni, Dr. D. S Deshmukh (2017) [6] An Innovative design of solar water heater flat plate collector is developed and tested. The collector is made-up of rectangular aluminium having size 0.97 m X 1.81 m total surface area for heat conduction is 1.9845 m2 . The absorber is made of Aluminium box with one large surface exposed to sunlight having size 1.94 m x 1.1 m x 0.1 m, glass 4 mm thick toughened to cover the box large open surface, black paint for absorbing solar radiation and insulation layer. Maximum temperature of water obtained at outlet of collector is 73.3 0C. Also an innovative storage tank is investigated. The storage tank is made up of MS plate, 50 mm puff insulation, outer-cladding cover, inside coating with Fiber Reinforcement plastic and 60%-40% partition for hot and cold water. Due to this FRP coating thermal conductivity of tank material and night heat losses get reduced. In conventional hot water storage tank night temperature losses is found to be 9 0C while in modified FRP coating tank with partition night temperature losses is found to be 4 0C

International Journal of Scientific Engineering and Research (IJSER) (2015) [7] 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.

Journal of Engineering and Development, Vol. 18, No.2, March 2014 [8] The crucial point in designing any solar collector is to allow maximum possible amount of solar radiation to reach the absorber part of the collector, and concurrently, reducing thermal losses from the absorber to the minimum. Evacuated-Tube Solar Collector (ETSC) offers feasible solution to this problem. An evacuated tube is composed of two coaxial glass tubes forming an annulus (Figure. 1). The space between the two tubes is evacuated to eliminate convective losses. The outer tube is the transparent cover while the inner tube is the absorber which is coated from outside (vacuum side) with a selective paint to maximize solar absorptance. One end of the evacuated tube is closed while the other is left open. The solar collector usually incorporates several evacuated tubes forming a parallel array. Heat can be extracted from the tubes by a variety of ways. The simplest way is achieved by the direct connection of the tubes to the storage unit. The working fluid can be either a liquid or a gas. When water is used as the working fluid, it is directly circulated between the tank and tube cavity via natural circulation. The temperature range in this type is limited by water boiling point. However, air or other gases may also be used as working fluids which necessitates the use of an appropriate fan or blower to circulate the fluid.

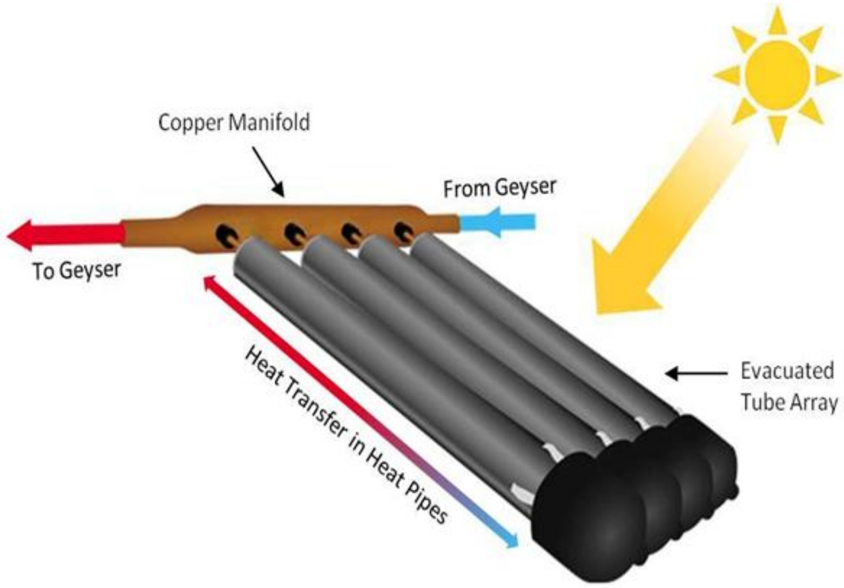
The first systematic study on an ETSC was done by Eberlein (1976) [9] . He analyzed thermal performance of an ETSC employing air as the working fluid. The solar collector studied by Eberlein consisted of an array of several evacuated tubes. Air is introduced in the middle way between top and bottom of each tube using additional concentric delivery conduit. It circulates in the annular space between the delivery conduit and the absorbing tube to collect solar thermal energy. This analytical study proposed several mathematical models useful in the design of air ETSCs but it was not validated by experimental tests. A detailed numerical study on the natural circulation inside the evacuated tube cavity was done by Gaa F.O. et. al. (1998)[2] . A numerical model of the inclined open thermosyphon has been developed using a finite difference algorithm to solve the vorticity vector potential form of the Navier-Stokes equations. The study was experimentally verified using laser doppler anemometry to measure the velocity profile at the tube exit.

Bae C.H. et. al. (2006)[9] experimentally studied a concentric evacuated tube solar collector with axially grooved heat pipe. The collector was designed, constructed, and tested at transient conditions to study its performance for different cooling water mass flow rates as well as different inlet cooling water temperatures. The experimental results showed that the mass flow rate has a significant effect on the collector efficiency. Subsequently, long term thermal performance of system can be predicted by giving an annual solar fraction of about 73% for all the hot water system of a house of four people in summer. A system similar to that studied by Eberlein was adopted by Kim J.T. et. al. (2007)[4] who conducted a numerical investigation of all-glass vacuum tubes with coaxial fluid conduits. Water (instead of air) is heated as it flows through the coaxial fluid conduit inserted in each tube. The space between the exterior of the fluid conduit and the glass tube inner surface is filled with antifreeze solution to facilitate the heat transfer between them. The study proposed one dimensional model that is validated by experimental data

Zhang X.R. and Yamaguchi H. (2008)[10] experimentally studied a different design of the working fluid pipe used to extract energy from the evacuated tube. They used a U-shape stainless steel pipe equipped with especially designed fin. One U-shape pipe with a fin is inserted in each evacuated tube. Supercritical CO2 is circulated in the U-shape pipe as the working fluid. The study shows the potential of using CO2 in power generation via evacuatedtube solar collector array
2. Experimental rig and test procedure: The experimental rig consists of five evacuated glass tubes manufactured by Shentai company (China) (Figures. 2 to 4). The specifications of the single tube is given in (Table 1). Each tube is filled with appropriate quantity of engine oil (about 2.5 L of 20W50 oil). The oil receives and collects the solar radiation penetrating the two walls of the evacuated tubes causing a rapid increase in its temperature. To convey the heat accumulated in oil, a locally manufactured stainless steel pipe (through-flow pipe) is inserted in the tube cavity so that the oil surrounds it. A single long steel pipe (14 m) is shared by the five evacuated tubes. The pipe is bent at 5 equally spaced locations to form 5 U-shape turns. Each turn is inserted in one tube. The steel pipe, thus, takes a serpentine shape going from tube to tube sharing the five tubes with the same water stream. This configuration resembles a serpentine flat-plate collector without an absorber plate. Water acting as working fluid is circulated inside the steel pipe by means of external pump. The pump is equipped with a regulation valve to control the amount of mass flow rate out of the pump. After adjusting the regulation valve the water mass flow rate is measured manually by measuring the time required to collect a specified amount of water in a graduated glass container. Pumping water in the steel pipe is necessary to maintain the flow of water through this long and small diameter pipe. Such a pipe exhibits high frictional losses which sometimes temporarily blocks the flow in the steel pipe (even with the pump being on) causing a fluctuation in the water mass flow rate. This intermittence in flow rate appears more clearly at higher temperatures when evaporation commences at some locations along the pipe. Sudden formation of bubbles inside the small diameter pipe (13 mm ID) considerably increases the frictional losses and causes a back pressure adverse to the pump head. Journal of Engineering and Development, Vol. 18, No.2, March 2014,

Cold oil is filled in the cavities of the five evacuated tubes at the start of the testing period (early morning hours). The period required for manually filling the five tubes (about 15 minutes) causes a rapid increase in oil temperature (ΔT=20oC) before starting the circulation of water in the stainless steel pipe. This rapid increase in temperature is expected since the convection losses from the oil is almost negligible and the oil quantity is relatively small (about 2.5 L per tube). Any amount of solar radiation penetrating the double-glazed tube is totally converted to an increase in oil temperature. Test are carried out for about 4 to 5 hours around the solar noon. The data are collected at an interval of 15 minutes. At each interval the water inlet and outlet temperatures are measured along with the oil temperatures at the first and last tubes. Solar radiation intensity (irradiance) and the ambient temperature are also measured and registered at each time interval. The water mass flow rate is kept constant all over the whole test period. The test are repeated for other values of mass flow rate on other testing days.

Bae C.H. et. al. (2006)[9] experimentally studied a concentric evacuated tube solar collector with axially grooved heat pipe. The collector was designed, constructed, and tested at transient conditions to study its performance for different cooling water mass flow rates as well as different inlet cooling water temperatures. The experimental results showed that the mass flow rate has a significant effect on the collector efficiency. Subsequently, long term thermal performance of system can be predicted by giving an annual solar fraction of about 73% for all the hot water system of a house of four people in summer. A system similar to that studied by Eberlein was adopted by Kim J.T. et. al. (2007)[4] who conducted a numerical investigation of all-glass vacuum tubes with coaxial fluid conduits. Water (instead of air) is heated as it flows through the coaxial fluid conduit inserted in each tube. The space between the exterior of the fluid conduit and the glass tube inner surface is filled with antifreeze solution to facilitate the heat transfer between them. The study proposed one dimensional model that is validated by experimental data



III. CONCLUSION

From our research we concluded that The solar water heater by evacuated tube can more efficient than the flat plate collector. We have concluded that the evacuated tube solar collector is a very efficient than other collectors in which 170 To 180 degree maximum temperature can be achieved. In this Literature work it has been concluded that present system is more compact and efficient compared to other solar water heater but the system is fragile because it is made of glass.

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