

A SURVEY ON EFFECT OF HEAT TRANSFER ENHANCEMENT ON SOLAR WATER HEATER BY EVACUATED TUBE HEAT PIPE

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Abstract

The Evacuated tube collector includes a number of rows of parallel transparent glass tubes connected to a header pipe and that are used in region of the blackened warmth absorbing plate we saw in the previous flat plate collector. Different types of glass materials of heat pipe have been used with different profile. Inside the fluid flow (octadecane) nano fluid on heat pipe. We found that they gives better temperature distribution and mass transformation in capillary tube of heat pipe

Keywords- *Heat Pipe, Evacuated Tube, CFD*

I INTRODUCTION

Evacuated tube solar collectors are extensively and widely used because it's good thermal insulation characteristics and insensitivity to the direction of sun light. Sabiha et al. made a comprehensive review on the progress and latest developments of evacuated tube solar collectors and why evacuated tubes are mostly preferred. There are three common types of evacuated tube solar collectors, which are (a) Water-in glass evacuated tube solar collector, (b) U-type evacuated tube solar collector and (c) evacuated tube heat pipe solar collector.

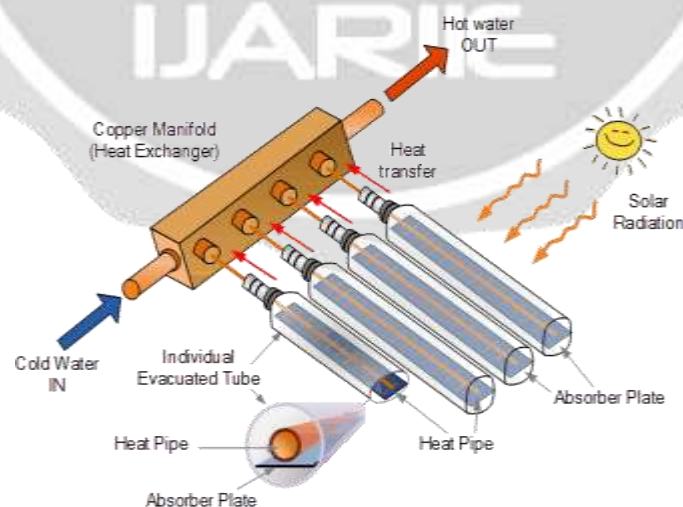


Figure 1.1 Evacuated tube collectors

The Evacuated tube collector includes a number of rows of parallel transparent glass tubes connected to a header pipe and that are used in region of the blackened warmth absorbing plate we saw in the previous flat plate collector. These glass tubes are cylindrical in form. Therefore, the attitude of the sunlight is continually perpendicular to the heat absorbing tubes which allows those collectors to perform well even when sunlight is low

including when it is early inside the morning or past due within the afternoon, or when shaded by using clouds. Evacuated tube collectors are especially beneficial in regions with bloodless, cloudy wintry weathers.

Evacuated tube collectors are made from a single or more than one rows of parallel, transparent glass tubes supported on a body. Each individual tube varies in diameter from between 1" (25mm) to 3" (75mm) and among five' (1500mm) to 8' (2400mm) in duration depending upon the producer. Each tube includes a thick glass outer tube and a thinner glass inner tube, (known as a "dual-glass tube") or a "thermos-flask tube" which is included with a unique coating that absorbs sun electricity but inhibits warmth loss. The tubes are fabricated from borosilicate or soda lime glass, which is robust, immune to high temperatures and has a excessive transmittance for solar irradiation. Unlike flat panel creditors, evacuated tube creditors do now not warmness the water immediately within the tubes. Instead, air is removed or evacuated from the space among the two tubes, forming a vacuum (for this reason the name evacuated tubes). This vacuum acts as an insulator lowering any warmth loss notably to the surrounding environment either via convection or radiation making the collector a whole lot greater efficient than the inner insulating that flat plate collectors have to offer. With the help of these vacuum, evacuated tube creditors commonly produce better fluid temperatures than they're flat plate counterparts so can also turn out to be very hot in summer.

Inside the every glass tube, a flat or curved aluminium or copper fin is attached to a metallic warmth pipe strolling thru the internal tube. The fin is included with a selective coating that transfers warmth to the fluid this is circulating through the pipe. This sealed copper heat pipe transfers the solar warmth via convection of its internal warmth transfer fluid to a "hot bulb" that not directly heats a copper manifold inside the header tank. These copper pipes are all related to a commonplace manifold that is then related to a storage tank, as a consequence heating the recent water in the course of the day. The warm water can then be used at night time or tomorrow due to the insulating properties of the tank.

The insulation houses of the vacuum are so correct that even as the inner tube can be as excessive as 150oC, the outer tube is cooler to the touch. This manner that evacuated tube water warmers can carry out well and can warmness water to fairly excessive temperatures even in bloodless climate while flat plate collectors perform poorly because of warmth loss.

However, the disadvantage is they can be lots more highly-priced compared to standard flat plate creditors or sun batch collectors. Evacuated tube sun creditors are well applicable to industrial and commercial hot water heating programs and may be an powerful alternative to flat plate collectors for home area heating, particularly in regions wherein it's far regularly cloudy.

Evacuated tube creditors are normal more modern and greater green compared to the standard flat plate collectors as they can extract the heat out of the air on a damp, dull overcast days and do no longer want direct sunlight to operate. Due to the vacuum inside the glass tube, the entire efficiency in all regions is higher and there may be a higher overall performance even when the solar is not at an best attitude. For these sorts of solar warm water panels, the configuration of the vacuum tube is what's genuinely essential. There are some unique vacuum tube configurations, unmarried wall tube, double wall tube, direct flow or warmth pipe, and those variations can determine how the fluid is circulated across the sun hot water panel.

Evacuated Tube Collectors are a totally green way of heating a good deal of your hot water use simply the use of the power of the solar. They can gain excessive very temperatures however are more fragile than other types of sun collectors and are a good deal extra pricey to install. They can be utilized in both an energetic open-loop (with out warmth exchanger) or an active closed-loop (with warmth exchanger) sun hot water system but a pump is needed to flow into the heat transfer fluid from collector to storage which will forestall it from overheating.

II Heat Pipe Evacuated Tube Collectors

Heat pipe evacuated tube collectors, a sealed heat pipe, usually made of copper to increase the collectors efficiency in cold temperatures, is attached to a heat absorbing reflector plate within the vacuum sealed tube. The hollow copper heat pipe within the tube is evacuated of air but contains a small quantity of a low pressure alcohol/water liquid plus some additional additives to prevent corrosion or oxidation.

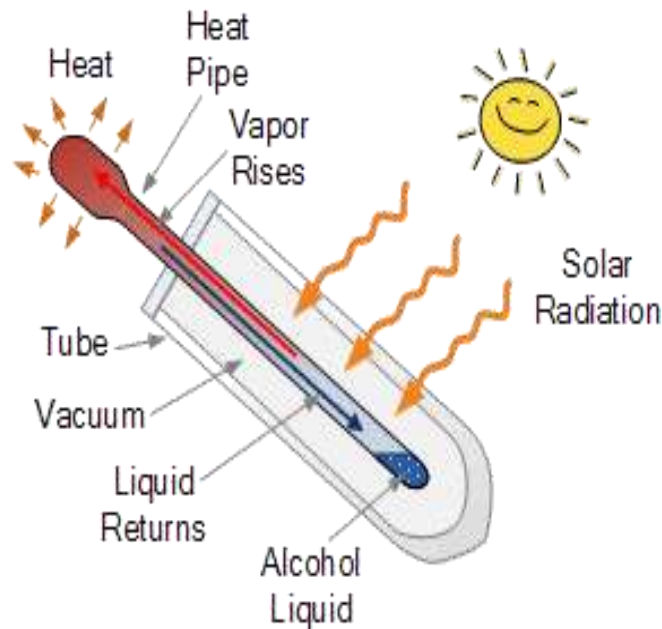


Figure 2.1 Heat Pipe Evacuated Tube Collector

This vacuum enables the liquid to vapourise at very lower temperatures than it would normally at atmospheric pressure. When sunlight in the form of solar radiation hits the surface of the absorber plate inside the tube, the liquid in the heat pipe quickly turns into a hot vapour type gas due to presence of the vacuum. As this gas vapour is now lighter, it rises up to the top portion of the pipe heating it up to a very high temperature. The top part of the heat pipe, and therefore the evacuated tube is connected to a copper heat exchanger called the “manifold”. When the hot vapours still inside the sealed heat tube enters the manifold, the heat energy of the vapour is transferred to the water or glycol fluid flowing through the connecting manifold. As the hot vapour loses energy and cools, it condenses back from a gas to a liquid flowing back down the heat pipe to be reheated.

The heat pipe and therefore the evacuated tube collectors must be mounted in such a way as to have a minimum tilt angle (around 30°) in order for the internal liquid of the heat pipe to return back down to the hot absorber plate at the bottom of the tube. This process of converting a liquid into a gas and back into a liquid again continues inside the sealed heat pipe as long as the sun shines. The main advantage of Heat Pipe Evacuated Tube Collectors is that there is a “dry” connection between the absorber plate and the manifold making installation much easier than with direct flow collectors. Also, in the event an evacuated tube cracking or breaking and the vacuum becoming lost the individual tube can be exchanged without emptying or dismantling the entire system. This flexibility makes heat pipe evacuated tube solar hot water collectors ideal for closed loop solar designs as the modular assembly allows for easy installation and ability to easily expand by adding as many tubes as you want.

III Direct Flow Evacuated Tube Collector

Direct flow evacuated tube collectors also known as “U” pipe collectors, are different from the previous ones in that they have two heat pipes running through the centre of the tube. One pipe acts as the flow pipe while the other acts as the return pipe. Both pipes are connected together at the bottom of the tube with a “U-bend”, hence the name. The heat absorbing reflective plate acts like a dividing strip which separates the flow and the return pipes through the solar collector tubes. The absorber plate and the heat transfer tube are also vacuum sealed inside a glass tube providing exceptional insulation properties.

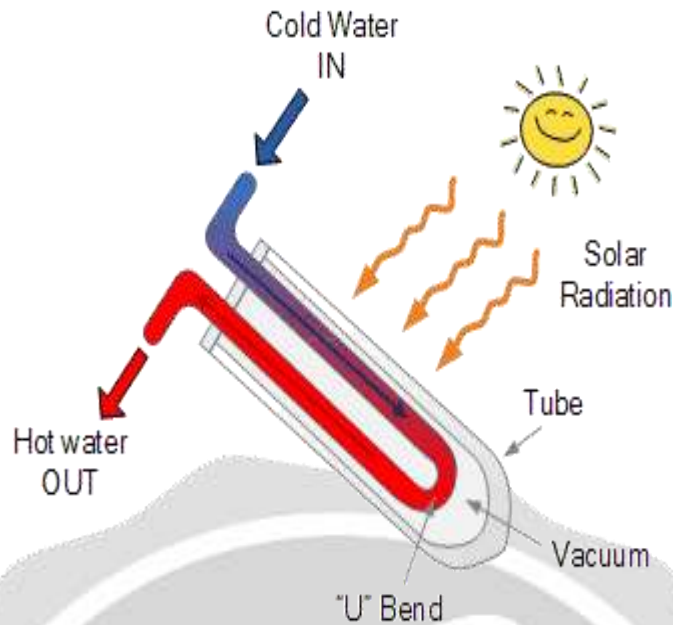


Figure 3.1 Direct Flow Evacuated Tube Collector

The hollow heat pipes and the flat or curved reflector plate are made out of copper with a selective coating to increase the collectors overall efficiency. This particular evacuated tube configuration is similar in operation to the flat plate collectors, with the exception of the vacuum provided by the outer tube.

Since the heat transfer fluid flows into and out of each tube, direct flow evacuated tube collectors are not as flexible as the heat pipe types. If a tube cracks or breaks it cannot be easily replaced. The system will require draining as there is a “wet” connection between the tube and manifold. Many solar industry professionals believe that direct flow evacuated tube designs are more energy efficient than heat pipe designs, because with direct flow, there isn’t a heat exchange between fluids. Also, in an all-glass direct flow construction the two heat tubes are placed one inside the other so the fluid being heated passes down the middle of the inner tube and then back up through the outer absorber tube.

Direct flow evacuated tubes can collect both direct and diffuse radiation and do not require solar tracking. However, various reflector shapes placed behind the tubes are sometimes used to usefully collect some of the solar energy, which may otherwise be lost, thus providing a small amount of solar concentration.

IV Literature review

M.S. Abd-Elhady et.al [1] - the investigation improves the heating capability of evacuated tubes that comprises heat pipes. Thermal oil is inserted in the evacuated tube in order to improve the rate of heat transfer, such that the mode of heat transfer from the inner surface of the evacuated tube to the heat pipe becomes convection via the oil, as well as conduction through the installed fin. The finned surface has been replaced by a foamed-copper. An experimental setup has been developed to study the influence of oil and foamed metals on the performance of evacuated tubes with heat pipes. It has been found that the bulb temperature as well as the heating efficiency of the evacuated tube heat pipe has increased in case of inserting oil in the evacuated tube and replacing the finned surface with foamed copper. Also, the thermal oil acts as a heat storage.

Sarvenaz Sobhansarbandi et.al [2]-this investigation to Solar water heaters (SWHs) are a well-established renewable energy technology that have been widely adopted around the world. In this study we have significantly improved the Evacuated Tube solar Collectors (ETCs) by utilizing the “dry-drawable” Carbon Nanotube (CNT) sheet coatings to increase the solar energy absorption and Phase Change Materials (PCMs) to increase the heat accumulation for application in solar water heaters. The proposed solar collector utilizes a phase change material namely Octadecane paraffin, with melting temperatures of 28 C which is categorized as non-toxic with longterm chemical stability PCM. As PCMs particularly in powder form may not be effective by itself due to the poor heat transfer rate, low thermal diffusivity and thermal conductivity, by combining CNT layers with the high thermal

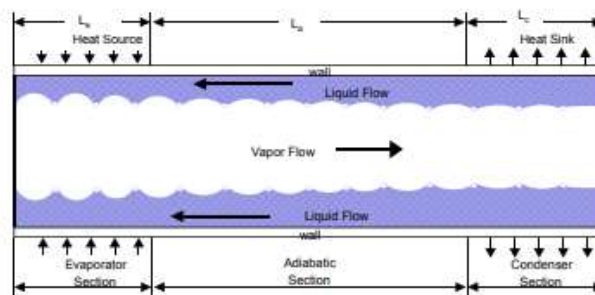
diffusivity and thermal conductivity compare to phase change materials, we are able to overcome the shortcomings of PCMs and design an innovative and efficient solar water heater. With the current technology, we can provide a near ideal black body surface, absorbing a maximum of 98%, between 600 and 1100 nm, of solar light striking the surface, and providing additional spectral absorption which improves the performance of the solar heater. Applying CNT sheets in conjunction with PCM enables heat storage directly on the collector for a more constant output, even on a cloudy day and prolonged output of heat at night.

S. SivaKumar et.al. [3] - the investigation the Renewable source of energy is the future energy source that meets out our demand for energy. In this solar energy is one of the prime sources. The harnessing of the solar energy can be done in both ways Solar (PV), Solar Thermal. Solar thermal finds more suitable for domestic needs such as Space Heating, Cooling, Hot water systems, drying. Hence the need for producing thermal energy from the collectors is important. Out of all the thermal collectors the evacuated tube solar collector (ETSC) is found to have the best efficiency with low solar insolation. In this paper the evacuated tube is modelled with heat pipe for the enhancement of the heat generated from the collector. The objective of this research is to design and investigate the heat transfer analysis of Heat Pipe Evacuated Tube solar collector is made of Borosilicate glass with length 1.8m and 0.058m and 0.049m diameter of outside and inside tubes for the Coimbatore location.

A.E. Kabeel et.al [4] - the investigation Modified coaxial heat pipes have been designed and manufactured to improve the thermal performance of the glass vacated solar collectors. Heat pipes were made up of two concentric copper tubes so that the annulus volume space between the concentric tubes was charged with refrigerant. In addition, the air as the working fluid at four different mass flow rates 0.0051, 0.0062, 0.007 and 0.009 kg/s flows through the inner tube of the heat pipe to the flow through the annulus between the heat pipe and glass evacuated solar tubes. The effect of the tilt angle of the evacuated tube on thermal performance of the evacuated solar tube collector was examined to obtain the optimum tilt angle during the experiments period. The influence of filling ratio for the two types of refrigerant R22 and R 134a on the thermal efficiency of the coaxial heat pipe solar collector at filling ratio range from 30% to 60% was conducted experimentally. Results show that the maximum increased in the thermal efficiency reached 67% corresponding to without heat pipes at mass flow rate 0.009 kg/s. The experiment results showed similarity between the two refrigerants.

Piotr Felinski and Robert Sekret [5] - this investigation a novel concept of using a phase change material (PCM) to store thermal energy directly within a heat pipe evacuated tube collector equipped with a compound parabolic concentrator (CPC). The excellent insulating properties of evacuated tubes and the use of latent heat are significant advantages of a PCM integrated evacuated tube collector/storage (ETC/S) over traditional solar water heaters. However, during the charge cycle of the ETC/S, direct solar radiation only reaches the exposed area of the evacuated tubes, which results in uneven heating of the PCM due to a lower energy input in the shaded area. This can be prevented by using a CPC to concentrate the solar radiation on the shaded area of the evacuated tubes, thereby raising the temperature of the PCM and quantity of stored heat. Therefore, a polished, thin aluminum sheet was used as low cost CPC with a concentration ratio of 1.2x. Technical grade paraffin with an onset melting temperature of 51.24 C was used as the PCM. The results from this study showed that the application of the CPC caused the temperature of paraffin on the shaded side of the evacuated tubes to increase more rapidly, especially during and after melting of the paraffin. Furthermore, the use of a CPC in a PCM integrated ETC/S improved the average gross charging efficiency from 31% to 36% and the maximum charging efficiency from 40% to 49%.

V Pressure Differential at Liquid Vapor Interface



- The vapor pressure decreases as it flows from the evaporator to the condenser.
- The liquid pressure decreases as it flows from the condenser to the evaporator.
- At any cross section of the heat pipe, a pressure differential exists between the vapor and liquid phases. This delta pressure is sustained by the surface tension force developed at the liquid/vapor interface at the tip of each groove.

- The lowest delta pressure occurs at the very end of the condenser (zero). The highest delta pressure occurs at the very end of the evaporator.

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