International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

EXPERIMENTAL STUDY OF FLAT PLATE SOLAR COLLECTOR BY USING HEAT PIPES

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ABSTRACT

The reduction of energy consumption has become a priority for all countries in the world. This fact is due to the limitation of earth's natural resources, global warming and increasingly high costs of energy consumption. Using renewable source is an efficient concept since it reduces dependency on fossil fuels. The sun is said to be the mother of all types of energies obtained from nature. Heat pipes are able to dissipate substantial amount of heat with a relatively small temperature drop along the heat pipe while providing a self-pumping ability due to an embedded porous material in their structure. Solar flat plate collector, consists of transport tubes; but in a heat pipe solar collector, it is replaced by heat pipes and, it works as a heat exchanger in which evaporator and condenser section exist in same unit The thermal performance of evacuated solar collector using the heat pipe was investigated. An optimized working fluid in the solar collector and charging (Lc /Le) ratio were studied. The main purpose in this study is the increase of collective efficiency of the evacuated solar collector using various experimental factors. The evacuated solar collectors using the heat pipe were investigated in the different operating conditions for outdoor experiment equipment. Heat exchanger, though considered under vast category have some disadvantages as compared to heat pipe as far as thermal energy storage concept is considered.

Keywords: **:- Heat pipes, Absorber Plate, Effectiveness, Solar Collector.**

1. INTRODUCTION

Renewable energy is very sustainable. The system using this energy can be a good alternative to solve the problem of the depletion of fossil fuels. Renewable energy consists of solar, wind, fuel cell, hydrogen, bio, geothermal, waste, coal liquefaction and gasification. Among these things, solar energy absorbs radiation energy from the sun and converts it into heat energy. And this energy will be essential to solve the pollution problem and it will be a good clean energy source. Heat Pipe are variously classified by material of container, a sort of working fluids, a class of capillary tube structure, anti-gravity action, geometric internal shapes, working temperature and charging ratio. Lot of studies for the heat pipe performance were conducted, but the study of solar collector using heat pipe was not enough to analyse its performance. The solar energy collector with evacuated tube can maximize the heat efficiency when it operates in the middle range of temperature (80 to 120 ℃) unlike flat-plate solar collector primarily using at home. Heat pipe receives solar thermal energy and the temperature in the heat pipes can be reached to 200℃. For collecting solar energy in the middle of temperature range, high efficiency heat pipe is necessary. Therefore, this study is focusing on the feasibility of applying Heat pipe to solar collector. A heat pipe is a device that efficiently transports thermal energy from its one point to the other. It utilizes the latent heat of the vaporized working fluid instead of the sensible heat.

A heat pipe consists of a sealed container, a wick structure, a small amount of working fluid that is just sufficient to saturate the wick and it is in equilibrium with its own vapour. The operating pressure inside the heat pipe is the vapour pressure of its working fluid. The length of the heat pipe can be divided into three parts viz. evaporator section, adiabatic section and condenser section. In a standard heat pipe, the inside of the container is lined with a wicking material. Space for the vapour travel is provided inside the container.

2. LITERATURE REVIEW

There exists a need to study different theories related to the work. They are as under.

2.1Latent Heat Thermal Energy Storage

Latent heat thermal energy storage is attractive due to its property of high energy storage density. When compared to conventional sensible heat energy storage system, latent heat energy storage system requires a smaller weight and volume of material for a given amount of energy. Furthermore, latent heat storage stores fusion heat at a constant or near about constant temperature which correspond to the phase transition temperature of the PCMs. In practice, solid-liquid phase change is preferred because of simultaneous slight volume variation and high enthalpy variation.

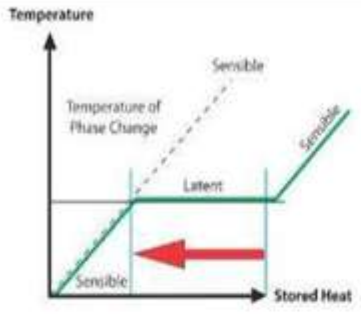

Fig. 1 Principle of Latent Heat Storage

2.2 Phase Changing Material

The thermal storage/release technology based on the use of phase change materials (PCMs), which possess a great capacity of accumulation energy for consideration as heat storage media, has raised an important practical interest. This is mainly due to the high energy storage density during phase change process within a very narrow temperature range. These materials are used in applications where it is necessary to store/release energy tanks to the temporary phase change between the offer and demand of thermal energy.

However, as is well known, most inexpensive PCMs are characterized by low thermal conductivity for the solid and liquid phases, limiting the rates of solidification and melting. The large thermal resistance posed by the PCM has limited the use of LHTES in emerging applications such as large scale power generation in conjunction with concentrating solar technologies, and novel LHTES systems have been receiving increased research attention (e.g., One approach to compensate for the low thermal conductivity of PCMs is to use heat pipes or thermosyphons that are embedded in a PCM to increase heat transfer rates between a hot (cold) external fluid and the PCM solid–liquid interface during melting (solidification). Since heat pipes utilize vaporization and condensation of a heat pipe working fluid, they can operate with very low thermal resistance, with overall PCM phase change rates determined by a rather complicated conjugate heat transfer process involving the heat pipe (or thermo syphon) and the PCM. Moreover, compared to solid fins of similar dimensions heat pipes have a low thermal capacitance, further improving PCM melting or solidification rates. While selecting PCM, melting Temperature requirement should be fixed. Here, the requirement is at about 50°c. accordingly the PCM is selected.

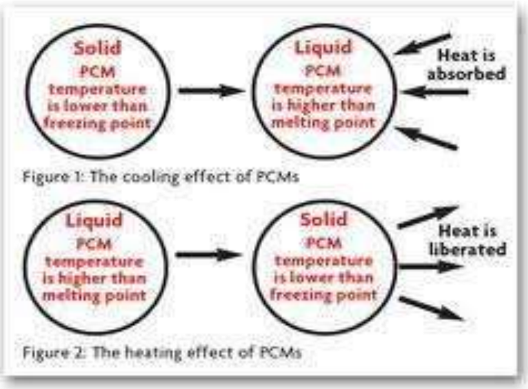

Fig 2.Principle of PCM

2.3HEAT PIPES-In Brief

Heat pipes were developed especially for space applications during the early 60´ by the NASA. One main problem in space applications was to transport the temperature from the inside to the outside, because the heat conduction in a vacuum is very limited. Hence there was a necessity to develop a fast and effective way to transport heat, without having the effect of gravity force. The idea behind is to create a flow field which transports heat energy from one spot to another by means of convection, because convective heat transfer is much than heat transfer due to conduction. A typical heat pipe consists of a sealed pipe or tube made of a

IJARSE
ISSN: 2319-8354

material with high thermal conductivity such as copper or aluminium at both hot and cold ends. A vacuum pump is used to remove all air from the empty heat pipe, and then the pipe is filled with a fraction of a percent by volume of working fluid (or coolant) chosen to match the operating temperature. Alternatively, the pipe is heated until the fluid boils, and sealed while hot. Examples of such fluids include water, ethanol, acetone, sodium, or mercury. Due to the partial vacuum that is near or below the vapour pressure of the fluid, some of the fluid will be in the liquid phase and some will be in the gas phase. The use of a vacuum eliminates the need for the working gas to diffuse through any other gas and so the bulk transfer of the vapour to the cold end of the heat pipe is at the speed of the moving molecules. In this sense, the only practical limit to the rate of heat transfer is the speed with which the gas can be condensed to a liquid at the cold end.

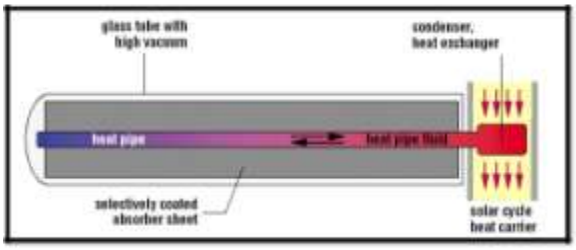

Fig 3.Principle of Heat pipe

It is also used at the Alaska pipe line, where you use the low temperature of the ground to cool the transported fluid down. The basic idea of heat pipes is based on an evaporation and condensation process. At the hot side, the working fluid is evaporated and at the cool side it condensates again

2.4 Operation

A heat pipe is broadly divided in three sections namely, evaporator, adiabatic and condenser. A typical heat pipe as shown in Fig 3 has one evaporator section that takes heat from a source. The heat absorbed in the evaporator causes change of phase of the working fluid and liquid changes to vapour. The increased vapour pressure in the evaporator causes the vapour to exit from the evaporator section and it travels through the adiabatic section. By Traveling the adiabatic section, vapour reaches the condenser region where condensation rejects the latent heat of the fluid to the sink. The condensed liquid is pumped back to the evaporator by a combination of the capillary pumping action and/or bulk forces. This fluid cycle is repeated during the normal operation of the heat pipe and can continue as long as there is sufficient vapour pressure and capillary pressure to support this operation At the evaporator end the liquid recedes into the wick pores so the menisci in the pores at the vapour interface are highly curved. On the other hand, the liquid menisci at vapour interface in the condenser end are almost flat. This difference in the interface curvature of the menisci at the vapour interface coupled with the surface tension of the working fluid causes a capillary pressure gradient at the liquid-vapour interface .This capillary pressure gradient pumps the working fluid against various pressure losses such as friction, inertia and against body forces. This is illustrated in Fig 3

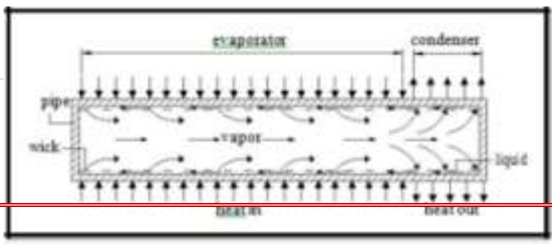

Fig 4.Schematic of operation of Heat pipe

3. . WICK STRUCTURE

The wick provides a means for the flow of liquid from the condenser to the evaporator section of the heat pipe. It also provides pores that are required at the liquid–vapor interface for development of the required capillary pressure. An effective wick requires large internal pores in a direction normal conductive heat flow path for minimization of the radial surface to liquid–vapor surface temperature drop. To satisfy these requirements, following types of wick structure have been developed to the heat flow path. This will minimize liquid flow resistance. In addition, small pores are required for the development of high capillary pressure and a highly conductive heat flow path for minimization of the radial surface to liquid–vapor surface temperature drop.

Mostly Sintered, grooved and mesh type of wick structures are being used in Heat pipes .Out of these three, the sintered metal has proved to be the best.

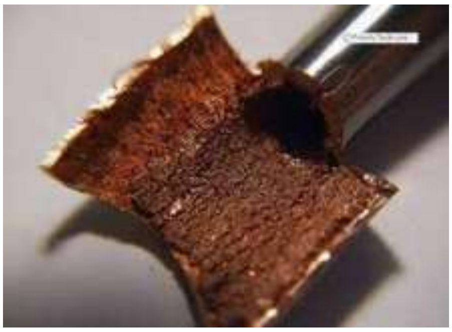

Fig 5.Sintered wick Structure

4. FLAT PLATE COLLECTOR

The flat-plate collector is the simplest and one of the most effective means of collecting solar energy for use in systems that require thermal energy at comparatively low temperatures. It is now recognized that with the rapid depletion of fossil fuels, solar energy will be increasingly utilized. In comparison with collectors of the concentrating type, such as those used in high-temperature solar- furnace applications, flat-plate collectors offer these **Advantages:**

(1) no complicated mechanisms for following the apparent diurnal motion of the sun are needed for their operation,

(2) Construction is simple and cost relatively low, and Diffuse as well as direct solar radiation is utilized. This last advantage is especially important in view of the fact that, of the total solar radiation received on the surface of the earth.

Basic to the design of any solar-energy utilization system in which fiat-plate collectors are used is the long-term average performance of these collectors. The long-term average performance, instead of the instantaneous rate of energy collection, is needed since the latter is extremely variable due to differences in cloudiness; since sufficient heat storage is usually provided, the average energy collection is also the useful energy collection.

This invention relates to solar heat collectors and has particular reference to flat plate collectors adapted to be located in a position to intercept and absorb solar radiation and to transfer the resultant heat to a fluid circulating within suitable conduits associated with the collectors. The protective glass panes are usually coated with low iron glass which promotes light and heat absorption while avoiding reflection. Flat plate collectors absorb the direct beam and diffuse solar radiation and are suitable for applications requiring moderate temperatures in the range of 50-100°C above ambient temperature. This is the requirement of project. They are fixed usually at an angle equal to the latitude of the location and the mechanical structures are simple since tracking is not required which again translates to little or no maintenance

5. EXPERIMENTAL INVESTIGATION

The Experimental Investigations are being carried out in summer season in Pune in 2018.

5.1Methodology and Operation

We started the work of this project with literature survey. We gathered many research papers which were relevant to this topic. After going through this paper we came to know about various technologies After this we started with rough drawing of project in Auto-CAD. We have drawn rough 2D drawing of our set up. While drawing we decided different components that will be used in our project. Once we got this we started preparing report and presentations for semester-VII. After successful completion of this we will start with actual design part. We will do calculations for main components that will be used in our project. Through this we can get exact dimensions of different components. After getting all dimensions we will start drawing of our project in CATIA. Once the 3D model is made we will start with the manufacturing part. One by one component will be manufactured and after its completion assembly part will be done. When assembly is completed we will do testing of our model. Simultaneously report work will be done for preparing final report.

The flat plate solar collector is a means of converting radiant energy from the sun into useful thermal energy. In this type of collector, the area of the absorber is equal to the area intercepting the radiant energy. The collector normally has some means of transferring the heat to a working fluid .This panel is to design to operate at temperatures up to about 100°C above ambient The purpose of this project was to research the use of heat pipes in flat plate solar collectors. Heat pipes are passive devices that have· the equivalent of a high thermal conductance. Because of this, they can be used to. Remove heat from a flat plate collector and transfer the energy *to* the working fluid of a distribution system.

Fig.6 Photographs of Actual Site

6. .RESULTS AND DISCUSSIONS

Day by Day sun ray intensity increases, maximum temperature is achieved. First reading is not satisfied our requirement for model but after some days readings are noticeable and intense.

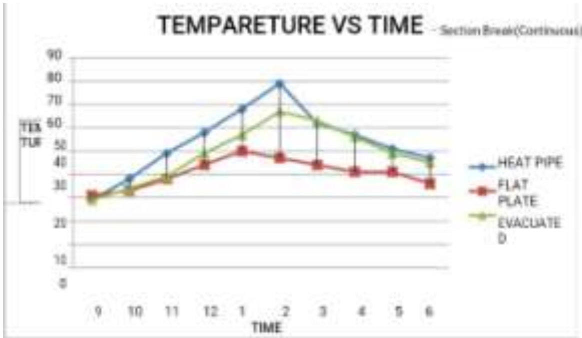

Fig.7 Result graph

The comparison between Heat Pipe, Flat Plate and Evacuated Tube as shown in graph. In that it is seen, the Heat Pipes Solar Panel are more efficient than the other two Solar Collector Panel.

7. CONCLUSION

Heat pipe is a thermal super conductor under certain heat transfer condition they can transfer the heat energy 100 times more than available best conductive materials, because of negligible temperature Gradient exist in heat pipe. The heat pipe has compactness, light weight, reversible in operation and high thermal flux handling capability makes heat pipe to use new modern era and in many wide variety application to overcome critical heat dissipation problem.

By using HEAT PIPE in Solar Collector the efficiency increases by 1.5 times more that the Convectional Solar Collector.

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