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Experimental study of evacuated tube two phase closed thermosyphon (tpct) solar collector with nano fluid.

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ABSTRACT

The demand for energy is severely increased as the world's population is quadrupled in the last half century. Engineers, researchers and technocrats have been developing renewable technologies in order to meet these global energy challenges. Solar energy is cleaner and the most promising renewable energy source. Now a day's use of nanofluids in solar-thermal technology for heat transfer enhancement is topic of interest. In this work study evacuated tube Two Phases Closed Thermosyphon (TPCT) is used. The objective of proposed work is to study experimental performance of heat pipe evacuated tube solar collector, which uses the circular heat pipes with CuO-H_2O nanofluid. Thermal performance of nanofluid charged Two Phases Closed Thermosyphon evacuated tube solar collector is better than conventional heat pipe evacuated tube solar collector. The enhancement in instantaneous collector efficiency obtained is 18-20%. At the same time effect of inclination angle and mass flow rate on performance of heat pipe evacuated tube collector is also studied.

Keywords— **evacuated tube, nanofluid, solar collector, thermosyphon.**

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I. INTRODUCTION

To study the thermal performance and enhancement of heat transfer rate of wickless heat pipe evacuated tube solar collector using nanofluid and its comparison with conventional ETC, it is necessary to develop the combined system in the same evacuated tube solar collector (containing eight heat pipe with evacuated tubes), out of which four evacuated tubes containing the conventional fluid as water and remaining four tubes containing the nanofluids, with other accessories and measuring instruments required for measuring required parameters to determine performance characteristics of both these collectors. The arrangement can be made to vary the inclination angle and vary the mass flow rate of water.

Objectives for this project are:

1. To study the effect on heat transfer rate and efficiency of evacuated tube collector using nanofluid. The effects are to be compared with evacuated tube wickless heat pipe containing conventional working fluid water.

2. To study the effect of orientation of evacuated tube collector on its performance i.e. performance of solar collectors at various tilts angles. Thermosyphons are two phase heat transfer devices with a very high effective thermal conductivity. Thermosyphon needs very small area, simplicity of design, high rate of heat transfer, lighter in weight, cost effective and less maintenance are its biggest advantages. A typical two phase closed thermosyphon consists of metal pipe with fixed amount of working fluid sealed inside. The hollow centre of the heat pipe is a vacuum so even at low temperature the fluid will vaporize. The vapour rises to the tip of the heat pipe and heat is transferred to the water flowing through manifold. Due to this heat transfer vapour will condense and flow back down the heat pipe so that this this process will be repeated.

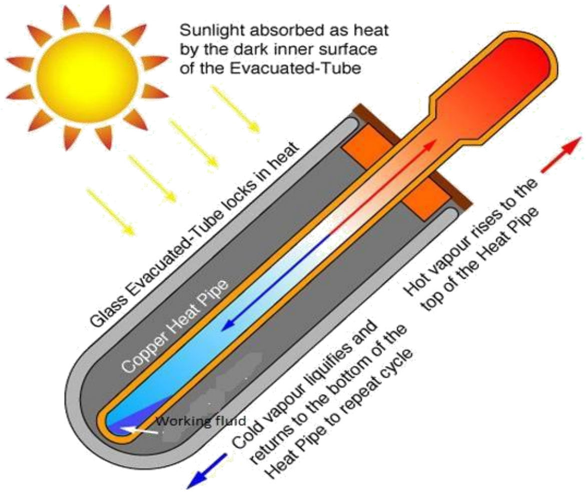

Fig. 1-a- Evacuated Tube Heat Pipe

Fig. 1-b- Evacuated Tube Heat Pipe

II. LITERATURE REVIEW

Stephen U.S.Choi and Jeffrey A. [1] in this paper they have proposed an innovative new class of heat transfer fluids can be engineered by suspending metallic nano-particles in conventional heat transfer fluids. The resulting ‗nanofluids' shows high thermal conductivity as compared to conventional heat transfer fluids. In this paper the results of theoretical study of thermal conductivity of nanofluids with copper nanoparticles is presented.

R shanthin and R. Velraj [2] discovered that recent pioneering advancement in the use of nanofluids as the working fluid in the two phase gravity assisted thermosiphon

(TPGAT) significantly improved the heat transfer performance. In the present study, the performance enhancement of TPGAT using carbonaceous and metal based nanofluids as the working fluid is investigated. The experiments are conducted at various heat input in the evaporator and at different fill ratios. The results of the experiments revealed that the nanoparticles play a major role in enhancing the performance by bombarding the formation of vapour bubbles in the evaporator section. It is also found that the fill ratio has varying role in the condenser and evaporator section at various heat input of the evaporator section.

P.G. Anjankar, Dr.R.B.Yarasu [3] in this paper the thermal performance of a vertical two phase closed thermosiphon with different flow rate to condenser and different inputted heat to evaporator with different condenser lengths has been investigated experimentally. There are three lengths of condenser 450mm, 400mm; 350mm has been tried out. It is found that the thermal performance of thermosyphon at flow rate 0.0027 Kg/s and heat input 500 W with condenser length of 450 mm is higher. The paper also reviewed the thermal performance of two phase closed thermosyphon. The objectives of the present work are to study the new design and thermal performance of thermosyphon.

Vishal Dabra, Laxmikant Yadav, Avadhesh Yadav [4] in this paper evacuated tube solar air collector is used with different tilt angles with the horizontal. Experimental results shown that tilt angle had significant influence on the thermal performance of evacuated tube solar air collector. Experiments shown that collectors with 30° tilt angle collector has better thermal performance than 45°.This shows that increasing tilt angle has no positive effect on thermosyphon phenomenon inside evacuated tubes.

Lin Lu, Zhen-Hua Liu, Hong-Sheng Xiao [5] in this indoor experiment was carried out to study the thermal performance of the open thermosyphon using respectively the deionised water and water based CuO nanofluids as the working liquid. Experimental results revealed that optimal filling ratio to the evaporator are 60%. CuO nanofluid significantly enhances the heat transfer as compared to deionised water.

Ahmet Samanci and Adnan Berber [6] in this study there is an experimental performance comparison between single– phase and two phase closed-thermosyphon solar water heater systems (SWHS).Two identical small-scale SWHS were constructed side by side. Tests were performed under same environmental conditions. In first system water was used as working fluid in the conventional SWHS called single-phase. In the second one R-134a was used as working fluid in two phases SWHS. In both the systems temperature readings of collector inlet and outlet and water storage tank were taken. Efficiency values of single phase and two phase systems were determined by using instantaneous solar radiation values available. After comparing results it is found that as compared to single phase system two phase system is 42.8% more efficient.

standard frame package for single roof installation. Manifold headers have capacities of 8 tubes. The collector manifold casing and end cap are made of powder-coated aluminium profile. The connection between the heat pipe and manifold is critically important to ensure optimal heat transfer. The heat pipe vacuum tube collects heat from incoming radiation. Thereafter, the condenser of the heat pipe will transfer the heat to the manifold where the water is heated.

The arrangement will be made in a fashion that the single heat pipe collector containing eight heat pipes will be divided in two parts. One part with four evacuated tube and heat pipe with conventional fluid as water. Whereas for remaining part the four heat pipes with working fluid as Cuo-H2O nanofluid with 1% volume concentration are inserted in

the existing evacuated tubes available in the collector.

A. Preparation of Nanofluids:

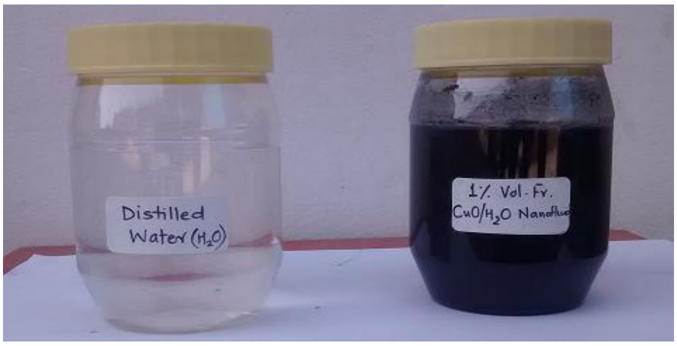

Fig. 2 Preparation of nanofluids

In this work nanofluid is prepared by two step process. Copper Oxide is purchased from SISCO laboratories Mumbai. The average particle size (APS) of CuO nanopowder is 40nm. This nanopowder is mixed with calculated proportion in distilled water. Mixture is stirred well for proper mixing of nanopowder. Afterwards this nanofluid is given for charging the heat pipes.

B. Test Methodology:

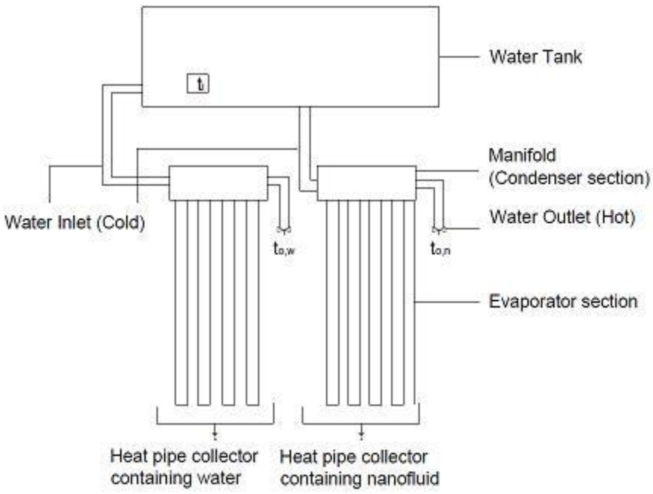

Fig. 3 Schematic arrangement of experimental Set-up.

Experimentation is carried out by placing collector facing towards south in May 2015. The effect of the tilt angle on the collector efficiency will be studied. The efficiency values of nanofluid and conventional fluid water are to be compared. Four temperature sensors are to be used to measure the fluid temperature at the inlet and outlet of the solar collector for ETC containing four TPCT with working fluid as water and four TPCT with working fluid as nanofluid. The ambient temperature is to be measured by a thermometer. The total radiations are to be measured with the help of radiation Pyranometer.

The cold water to be heated will be stored in the tank. The water will be passed to the inlet of the manifold through the condenser section of the evacuated tube solar collector. Set up will have mechanism to vary the tilt angle of the collectors. The testing will be carried out throughout the day from 10a.m to 4p.m. Readings will be recorded at half hour interval. The intensity of solar radiation will be measured by using Pyranometer. The inlet and outlet water temperature from both the collectors along with ambient air temperature will be measured using RTDs.

During the testing procedure, both the solar collectors were held in tilted position facing South and tested in outdoor conditions of Pune, India (latitude 18.52°N and longitude 73.85°E).Experiments were carried out throughout the day from 10:00am to 4:00pm and values of solar intensity(It) as well as different temperatures were recorded at each half hour interval. Different temperatures measured include ambient air temperature (Ta), inlet water temperature (Ti), and outlet water temperature for collector with water and nanofluid as working fluid (To, w and to, n resp.).It should be noted that each of these readings were obtained for a fixed mass flow rate. Tests were carried out throughout the day for various tilt angles, namely, 20°, 31.5 and 50° for a given mass flow rate 0.00125 kg/sec.

C. Formulae Used:

The rate of thermal energy input (Qin), the rate of thermal energy gain (Qg) and the instantaneous efficiency (η) of each collector is calculated as below:

Qin = It. Acoll

Where, Acoll is the area of each collector = 0.315 m2

Qg = m Cw (To-Ti)
Where m is mass flow rate and Cw is specific heat of water.
ηinst = Qg/Qin
Where ηinst is the instantaneous efficiency.

III. RESULTS AND DISCUSSION

Experiments were carried out to investigate the thermal performance of heat pipe solar collector by using working fluids for heat pipes as water and cuo-H_2O nanofluid. The results are depicted in Figs. 3-6. The variation of various parameters, namely, the rate of solar energy input, ambient air temperature, inlet water temperature and outlet water temperature for two different evacuated tube heat pipe solar collectors is shown in following figures.

IV. CONCLUSION

An experimental study has been carried out to investigate the thermal performance of two phase closed thermosyphon evacuated tube solar collector with working fluid in heat pipe as conventional fluid water and Cuo-H_2O nanofluid

.Following conclusions are made from experimental study and are detailed as below:

1. The thermal performance of solar collector with heat pipe containing nanofluid is better than that of conventional heat pipe collector. There is 18-20% rise in instantaneous collector efficiency due to nanofluid as a working fluid.

2. Experimental results also revealed that the collector tilt angle had crucial effects on thermal performance of evacuated tube collector. The optimum performance is obtained at 31.5° for both the collectors.

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