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REVIEW PAPER ON THERMAL PERFORMANCE INVESTIGATION OF EVACUATED TUBE HEAT PIPE SOLAR COLLECTOR WITH NANOFLUID

Mr.Mujawar.N.H.*, Prof.Shaikh.S.M.
* ME Heat Power Engineering Student. J.J.M.C.O.E.Jaysingpur Maharashtra, India.
Professor,J.J.M.C.O.E.Jaysingpur Maharashtra, India.

ABSTRACT
India is among the top five destinations worldwide for solar energy development. Flat plate or evacuated tube solar collectors may be used to gather solar energy in a non-concentrated manner for heating and cooling purposes. Due to their high efficiency and cost effective nature, this technology is becoming very popular worldwide and may be used year round, even in high humidity, cold temperatures, and/or generally poor weather conditions. Partly due to their increased efficiency over electric water heating, as of 2010, over 70 million residences worldwide had active installations of this technology. The basic construction of these systems consists of some type of absorption mechanism, a transfer mechanism, and some type of storage. A more efficient modification of this technology is the evacuated tube collector. In this configuration, heat pipes are vacuum sealed into a containment unit. These pipes are then used to transfer heat using a manifold. The evacuated tube construction is often preferred as it is 20–45% more efficient than flat plate solar collectors, achieves reduced heat loss by mitigating conductive/convective forces via vacuum sealing, uses inexpensive pipes that are durable and inexpensive to replace, and, due to the cylindrical nature of the pipes, tracks the sun passively leading to increased efficiencies at lower costs.

KEYWORDS: Solar Collector, Evacuated tube Heat Pipe, Nanofluid.

INTRODUCTION
Solar energy, being abundant and widespread in its availability, makes it one of the most attractive sources of energies. Tapping this energy will not only help in bridging the gap between demand and supply of electricity but shall also save money in the long run. A Solar Water Heating System (SWHS) is a device that makes available the thermal energy of the incident solar radiation for use in various applications by heating the water. The SWHS consists of solar thermal collectors, water tanks, interconnecting pipelines, and the water, which gets circulated in the system. Solar radiation incident on the collector heats up the tubes, thereby transferring the heat energy to water flowing through it. The performance of the SWHS largely depends on the collector's efficiency at capturing the incident solar radiation and transferring it to the water. With today's SWHS, water can be heated up to temperatures of 60°C to 80°C. Heated water is collected in a tank insulated to prevent heat loss. Circulation of water from the tank through the collectors and back to the tank continues automatically due to the thermosyphon principle. The hot water generated finds many end-use applications in domestic, commercial, and industrial sectors. The evacuated tube solar collectors perform better in comparison to flat plate solar collectors, in particular for high temperature operations. Evacuated tube solar collector system is better option for domestic utilization because of its simplicity and low cost. Many solar water heaters manufacturers in India are importing evacuated tubes from China.

Employing heat pipes for solar water heating application is at its young stage and extensive studies are required to integrate heat pipe in solar collector systems so as to improve the heat transport. As the demand of energy conservation increases, heat pipes become more and more attractive for an increasing number of various applications. Heat pipes have low thermal resistance for heat transfer than any other metals. Most of the above limitations of conventional solar collectors can be overcome by using a compact heat pipe solar collector system.Very high thermal conductance (phase change heat transfer), the ability to act as a thermal flux transformer and an isothermal surface of low thermal impedance are very important properties of heat pipe for solar system application.

The heat transfer rate of heat transfer devices like heat pipe can be enhanced by adding additives to the working fluids to change the fluid transport properties and flow features. Heat transfer limitations of heat transfer equipments can be improved by using nanofluid in it. As a result, the higher thermal performances of nanofluids indicate nanofluid potential as a substitute for conventional pure water in heat pipes. This finding makes nanofluids more attractive as a cooling fluid for devices with high energy density.

LITERATURE REVIEW

The conventional solar collector is a well-established technology with certain limitations. This has various applications such as water heating, space heating and cooling. However, the thermal efficiency of these collectors is limited by the absorption properties of the working fluid, which is very poor for typical conventional solar evacuated tube collector. Recently usage of nanofluids which is basically liquid- nanoparticles colloidal dispersion as a working fluid could found to enhance evacuated tube heat pipe solar water heaters thermal efficiency.

Lee et al. [1] performed research specifically on nanofluids with oxide particles at Argonne National Laboratory. This experiment examined Al2O3 and CuO nanoparticles dispersed in both de-ionized water and ethylene glycol and their related thermal conductivities as measured by the transient hot-wire method. A strong dependence on particle size and an almost linear increase of conductivity with volume fraction of the particles were found. CuO nanoparticles were found to have a greater heat transfer effect than Al2O3 particles, which was suggested to be due to the CuO particles being smaller.

Wang et al.[2] examined the thermal conductivity of Al2O3 and CuO nanoparticles dispersed in various base fluids, including water, ethylene glycol, engine oil and vacuum pump fluid. Thermal conductivity was measured by the use of the one-dimensional, steady-state parallel plate method. This experiment resulted in data that suggests a possible relation between thermal conductivity and the size of the nanoparticles, as well as the method of dispersion used.

M. A. El-Nasr and S. M. El-Haggar[3] investigated thermal performance of a wickless heat pipe solar collector on the basis of heat-transfer analysis using R-11, acetone, or water as a working fluid at different charging pressures. Also the effect of angle of inclination and the effect of liquid fill on the performance of the wickless heat pipe solar collector were studied. The experimental results show that the maximum efficiency occurs at 45° tilt angle. The optimum liquid fill in the wickless heat pipe with solar applications is 0.7, where the temperature flattening phenomenon occurred in the collector. The most suitable working fluid for wider temperature flattening is R-11 compared with acetone or water. The predicted theoretical results, using R-11, were compared with the experimental data and proved the validity of the theoretical analysis.

Mathioulakis et al. [4] has developed a solar collector experimental system comprising of heat pipe and water-storage tank, and analyzed the system performance. The obtained results showed that comparatively high efficiency could be achieved. It can be used for heat-pipe hot water system optimization.

Rittidech et al. [5] investigated the plate collector adopting a curved heat pipe and analyzed the influence of solar irradiance and ambient temperature on the collector performance. This analysis incorporates the natural forces of gravity and capillary action. It has additional benefits such as corrosion free operation.

Chun et al.[6] have studied the heat pipe solar water heater using different heat transfer medium and analyzed (experimentally) the temperature distribution pattern of the heat pipe under low level solar irradiance. It was focused on finding the most suitable configuration of the system for possible commercialization in Korea.

Hussein et al.[7] has investigated transient thermal behavior of heat pipe flat plate collector focusing on the influence of solar irradiance, the material and thickness of heat absorption plate, etc on the thermal performance of the collector.

Riffat et al. [8] presented a theoretical model for analyzing heat transfer processes in a thin membrane heat-pipe solar collector, and also the model results were validated through experimental data.

C.I.Ezekwe[9]analyzed the thermal behavior of solar energy systems using heat pipe absorbers and compared them with systems using conventional solar collectors.

Sandesh.S.Chougule et al. [10] designed and fabricated solar heat pipe collector to study its performance of the outdoor test condition. The thermal performance of the wickless heat pipe solar collector was investigated for pure water and nanofluid with varied range of CNT nanofluids concentration (0.15%, 0.45%, 0.60%, and 1% by volume) and various

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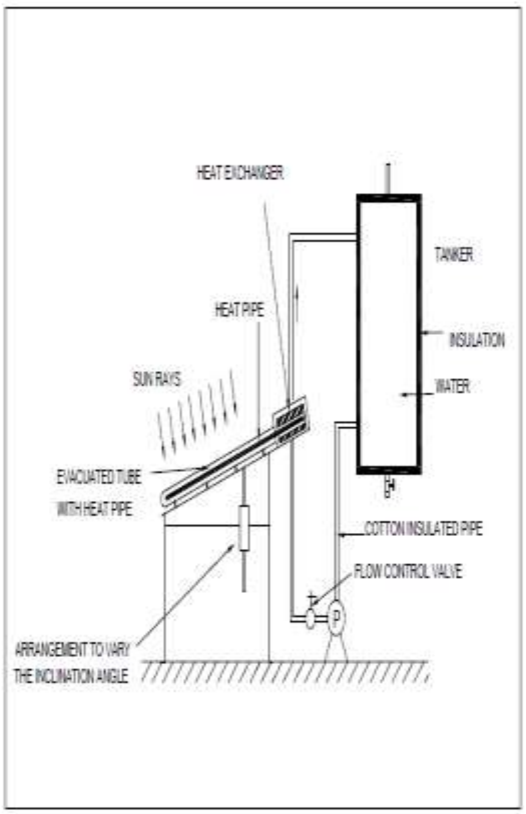
tilt angles (200, 320, 400, 500, and 600). CNT nanoparticles with diameter 10–12nm and 0.1–10μm length are used in the present experimental investigation. The optimal value of CNT nanofluids concentration for better performance is obtained from the investigation. The thermal performance of the heat pipe solar collector with CNT nanofluids is compared to that of pure water.

Bin Du et al.[11] designed experimental platform for testing solar collectors has and built at Southeast University, China. In this article, the structure and the detailed operation of this platform are presented. The performance of an evacuated heat pipe solar collector, in which a heat-pipe is used to transfer the heat from the collector to the water, is investigated experimentally by using the developed platform. The investigation is focused on the instantaneous efficiency and its correlations with the receiver and absorber areas, the effective heat capacity, the incidence angle modifier and the pressure drop. This platform is also suitable for experimental investigation of other types of solar collectors

CONCLUSION

The following conclusions can be drawn from the literature review carried above

- The evacuated tube solar collectors perform better in comparison to flat plate solar collectors and this is better option for domestic utilization because of its simplicity and low cost.
- Employing heat pipes for solar water heating application is at its young stage and extensive studies arerequired to integrate heat pipe in solar collector systems so as to improve the heat transport.
- The heat transfer rate of heat transfer devices like heat pipe can be enhanced by adding additives to the working fluids to change the fluid transport properties and flow features.
- Heat transfer limitations of heat transfer equipments can be improved by using nanofluid in it.
- It has been shown experimentally that, for a given concentration level, the thermal conductivity of the nanofluids increases with a decrease in particle diameter. At the same time, higher heat transfer coefficient can be seen when using nanoparticle in water under low heat input conditions
- As a result, the higher thermal performances of nanofluids indicate nanofluid potential as a substitute for conventional pure water in heat pipes.
- This finding makes nanofluids more attractive as a cooling fluid for devices with high energy density.



Schematics of proposed experimental system.

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