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Experimental Investigation on Cylindrical Heat Pipe with V-Trough Solar Collecting System

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Abstract- The purpose of the study was to investigate the cylindrical heat pipe with different working fluid such as Nano fluid (Tio_2) +DI water, Methanol and Ethanol on V-trough solar collecting system. Nano fluids are stable suspensions of nano fibers and particles in fluids. Latest investigations show better thermal behavior such V-trough solar collecting system with heat pipe as improved thermal conductivity and convection coefficients in comparison to pure fluid or fluid with larger size particles. Performance of the cylindrical heat pipe with V-trough solar collecting system was experimentally examined. The results shows when the heat pipe has Nano fluid(Tio_2)+DI Water as working fluid was performing better than Methanol and Ethanol. It was found that there is a significant rise in the thermal efficiency of the collector by using Nano fluid(Tio_2)+DI Water as working fluid in cylindrical heat pipe. The V-trough solar collecting system with heat pipe shows great potential in terms of higher absorption per unit area as compared to other conventional solar collectors. It was concluded that V-trough solar collecting system with heat pipe was best suited for domestic solar water heater applications for its low weight, low cost and long life etc.

IndexTerms- Nanoparticles, V-trough collecting system, cylindrical heat pipe, performance.

1. INTRODUCTION

Solar energy has always been a viable option for the energy problems faced by the world. Solar energy is the radiation resulted by nuclear fusion reactions in the sun. The 30% of the solar power actually reaches the Earth, every 20 minutes the sun produces enough power to supply the earth with its needs for an entire year[1]This solar radiation can be directly converted into heat. Many different kinds of equipment are available for this conversion. These can help lessen the impact of domestic sector on the environment. Flat plate collectors have been in service for a long time without any significant changes in their design and operational principles[2] Typically, conventional solar collectors (SC) use water pipes attached to the collecting plate where water circulates either naturally or forcibly and transfers the heat it collects to a storage tank. Some of the shortcomings of this type of solar collector systems include: the additional expense of a pump and the power to operate it; the extra space required for any natural circulation system; the corrosive effect of water; an, the limited quantity of heat transferred by the fluid. Heat-pipes offer a promising solution to these problems. The heat pipe is a device of very high thermal conductance; that is, it will transport energy without an appreciable drop in temperature [3]. The heat pipe is suitable for a wide range of applications including solar collector. In a heat pipe, the process is evaporation-Condensation convection. Thus, olar collectors with heat pipes have a lower thermal mass, resulting in a reduction of start-up time [4].Thermal diode is important in designing of solar collectors, where heat is transferred only from the evaporator to the condenser, but never in the reverse direction. This feature can cut off the heat loss when the absorber temperature is lower than that of the liquid in the heat exchanger [5-9].Several studies on heat pipe solar collectors are reported in the literature. Riffat, et al [5] studied developing a theoretical model to investigate thermal performance of a thin membrane heat-pipe solar collector. In their work thin membrane heat pipe solar collector was designed and constructed to allow heat from solar radiation to be collected ata relatively high efficiency while keeping the capital cost low. Azad [10] investigated the heat pipe solar collector theoretically and experimentally, and the optimum ratio of heated length-cooled length of the heat pipe. Hull [11] investigated heat transfer factors and thermal efficiency for heat pipe absorber array connected to a common manifold and predicted that array with less than ten heat pipes have significantly less efficiency than conventional flow-through collector. Hussein [12] investigated the different design parameters of the natural circulation two phase closed Thermosyphon flat plate solar water heaters using the verified expanded model. Radhwan, et al [13] investigated experimentally the thermal performances of two R11 charged integrated solar water heaters using forced and natural circulation water flows. The results showed that the inclination of the condenser integrated within the collector frame had remarkable effect on the natural circulation of the water flow system, while it had no significant effect on the forced circulation flow system. Therefore in the present study V -type absorber plate with flat plate heat pipe solar collector was designed, constructed and tested with different working fluid under real conditions with system installed outdoors conditions.

2. EXPERIMENTAL WORK

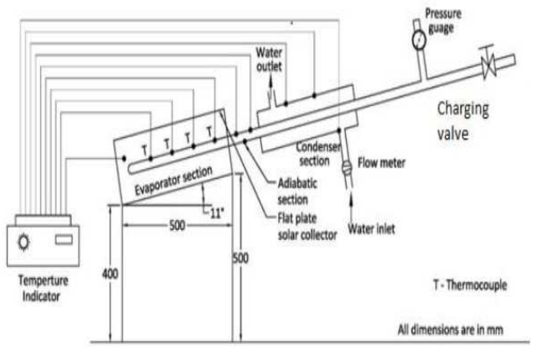

Fig 1 Schematic diagram of Experimental Setup

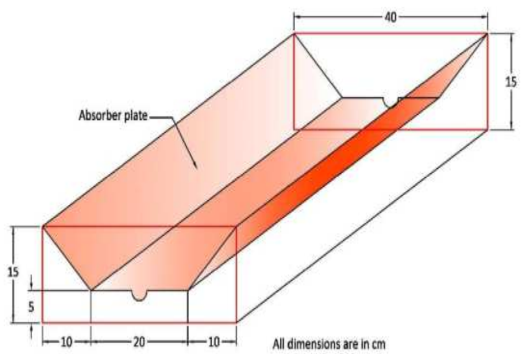

Fig 2 Schematic diagram of Absorber plate

A prototype of V -type absorber plate with flat plate heat pipe solar collector which was designed and constructed to collect and distribute heat by means of vaporization and condensation of a heat transfer fluid is shown in Figure 1. It comprised mainly one copper heat pipe with outside diameter of 12 mm and an evaporator length of 600 mm while the wick consisted of two layers of 100-mesh stainless steel screen fitted to the evaporator section. The evaporator section of the heat pipes are placed in V-type absorber plate of solar collector. The experimental setup consists of heat pipe, solar collector with V-trough absorber plate and Water storage tank. The heat pipe are placed on the grooved absorber plate and tied in a flat plate solar collector. Glass wool insulation was provided below the absorber plate for reducing the conduction losses, the sides of the absorber plate are covered using thermo cool insulator for minimizing the convective losses. The glass plate is used for reducing the radiation losses. By reradiating the heat emitted by the absorber plate in the form infrared rays. Number of glass plates used one or two, if not most of solar radiation will get refracted. Pyranometer was used to measure the solar intensity in m.v. The surface temperature of cylindrical heat pipe was measured using six K-Type thermocouples, absorber plate and glass plate temperatures are measured using T-Type thermocouples. All the thermocouples were connected to the temperature indicator. The uncertainty in temperature measurement was ±0.1°C.Flow to condenser section was controlled by rotometer and flow rate was maintained at120ml/min.

3. RESULTS AND DISCUSSIONS

Fig. 3 to 6 illustrates the temperature distribution of absorber plate and glass plate temperatures of solar collector with different working fluid in typical sunny days. Based on the obtained results from fig. 3 to 6 absorber and glass temperatures increase with time and have peak around 12.30 to 1.30 PM. The maximum obtained values for absorber plate and glass plate are 85 to 90 ˚C and 55 to 65 ˚C respectively. It is also obvious that in the early hours of the day the glass temperature is slightly higher comparison with absorber plate because the glass is directly faces the radiation and its temperature rises faster in comparison with glass temperature due to the higher heat losses from the glass to ambient.

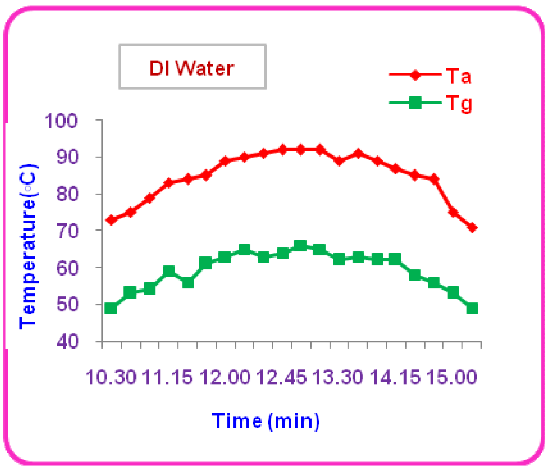

Fig 3 Temperature against Time (DI Water)

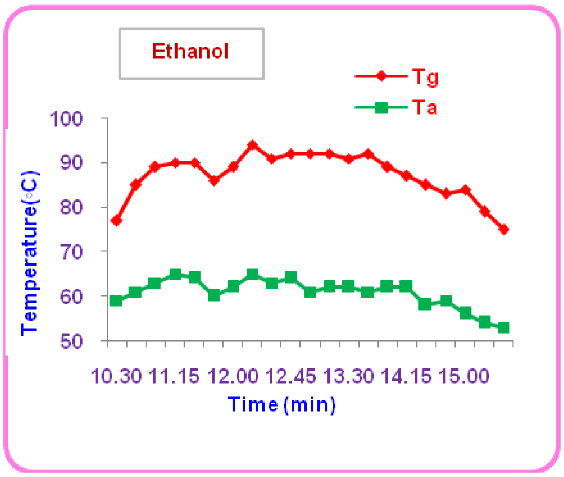

Fig 4 Temperature against Time (Ethanol)

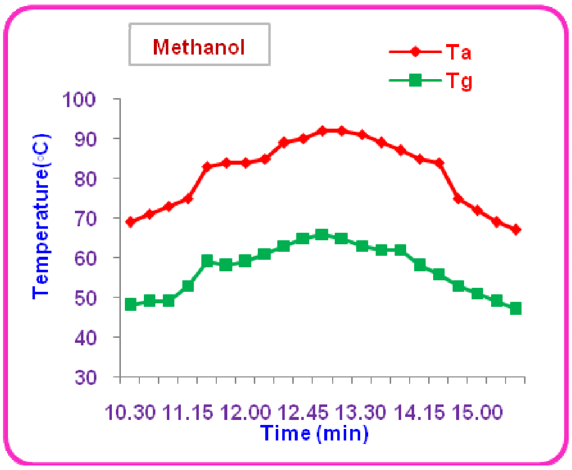

Fig 5 Temperature against Time (Methanol)

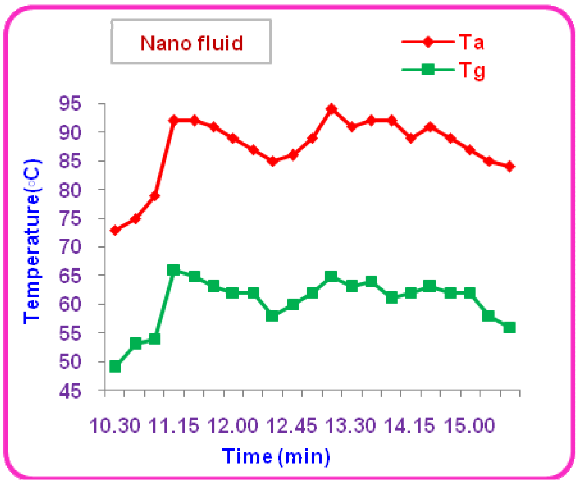

Fig 6 Temperature against Time (Nano Fluid)

Fig.7 to10 illustrates the temperature distribution of evaporator section of heat pipe was maximum at middle portion of evaporator section.Fig.11 illustrates the instantaneous efficiency of heat pipe against time for different working fluid such as nanofluid+ Di water ,methanol, ethanol, in which nano fluids as working fluid shows maximum instantaneous efficiency.

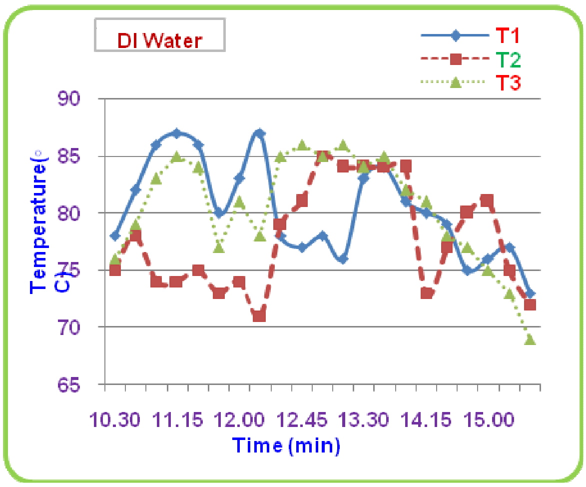

Fig 7 Evaporator Temperature of heat pipe against Time (DI Water)

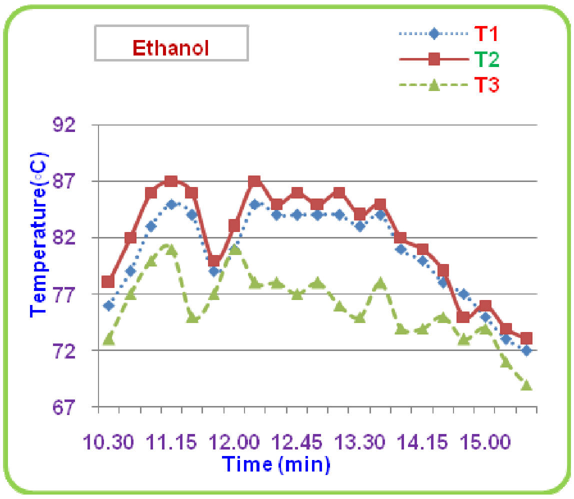

Fig 8 Evaporator Temperature of heat pipe against Time (Ethanol)

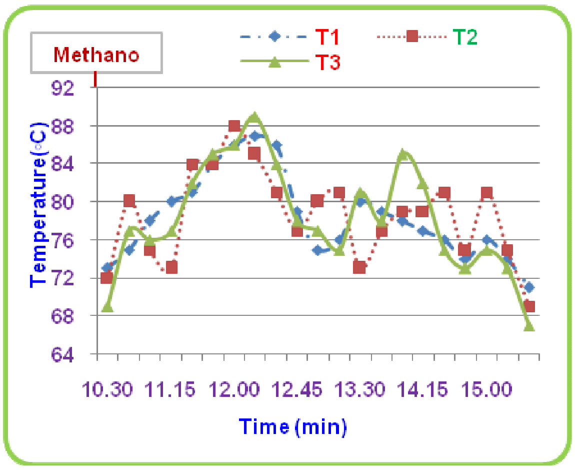

Fig 9 Evaporator Temperature of heat pipe against Time (Methanol)

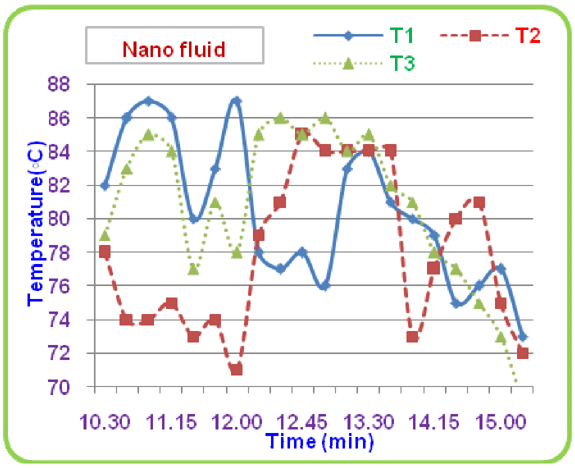

Fig 10 Evaporator Temperature of heat pipe against Time (Nanofluid)

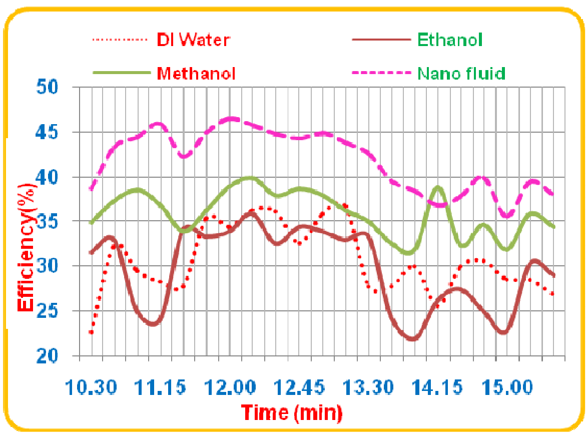

Fig 11 Efficiency against Time in min

4. CONCLUSIONS

Many studies have been under taken by various researchers on different types of solar collectors for various applications. The proposed design of V-trough solar collecting system with heat pipe was designed, fabricated and tested for various working fluid of heat pipe. The designed V-trough solar collecting system with heat pipe increase the solar intensity that enhance thermal performance of heat pipe. The instantaneous efficiency of the system was calculated. The performance analysis of the above test results shows that when the heat pipe has Nano fluid(Tio_2)+DI water as working fluid was performing better than DI water, Methanol, Ethanol. As the heat input increases the surface temperature of heat pipe increases. It was found that there is a significant rise in instantaneous efficiency of solar collector by using nano fluid as working fluid in heat pipe. V-trough solar collecting system shows great potential in terms of higher absorption per unit area as compared to flat absorber plate. The performance of the V-trough solar collecting system with heat pipe has been excellent when compared to other conventional solar collector. It is concluded V-trough solar collecting system with heat pipe was best suited for domestic solar water heater applications for its low weight, low cost and long life etc.

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