Enhancing the Performance of Solar Flat Plate Collector by Using Copper Oxide Nanofluid

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***Abstract*- Solar energy is one of the cleanest forms of renewable energy resources. The conventional solar collector is a well-established technology which has various applications in water heating, space heating and cooling. However, the thermal efficiency of this collector is limited by the absorption properties of the working fluid, which is very poor for typical conventional solar flat plate collector. Hence nanofluids are used as a working fluid to enhance solar flat plate collector's thermal efficiency. The objective is to increase the performance of solar flat plate collector using nanofluid. Copper oxide nanoparticles are mixed with water. The mixture will be used as a working medium to absorb the solar energy as maximum as possible to increase the efficiency of the solar flat plate collector. Copper oxide nanoparticle is selected because of its high thermal conductivity. In this the outlet temperature and pressure drop of the working medium is to be measured and the efficiency of solar flat plat collector and thermal conductivity of nanofluid and water will be compared and evaluated. The efficiency of solar collector is enhanced by 36%, 38%, 34% when copper oxide nanofluid is used as a working medium for mass flow rate of 0.016, 0.033, 0.05 Kg/s respectively. From the result it is concluded that copper oxide nanofluid is suitable to enhance the performance of solar flat plate collector.**

Key words: Solar energy, Solar flat plate collector, CuO nanofluid, Thermal conductivity.

I. INTRODUCTION

Solar thermal energy is by far the largest exploitable resource. It is a very convenient source of heating. It can be used free of cost, and does not need to be transported. The critical problem for solar thermal utilization is how to improve the efficiency of the solar collector. It can be performed with optimizing the structure of collector or developing a new type of working medium. Currently, water as a medium in solar thermal energy system is used widely. But the thermal conductivity of water is not high. With the development of nanotechnology, an innovative heat transfer fluid arises. Nanofluids, a relatively new class of fluids which consist of a base fluid with nano-sized particles (1-100 nm) suspended within them. These particles are generally metals or metal oxides. Nanofluids have been considered as a new-type heat transfer fluid because of their enhanced thermal conductivities. Recently some researchers have put forward to use the nanofluid as the working fluid for the solar collectors.

II. EXPERIMENTAL SETUP

A. Preparation of Nanofluid

Two-step method is the most widely used method for preparing nanofluids. Nanoparticles used in this method are first produced as dry powders by chemical or physical methods. Then, the nano sized powder will be dispersed into a fluid in the second processing step with the help of intensive magnetic force agitation using ultrasonic vibration. Two-step method is the most economic method to produce nanofluids in large scale, because nano powder synthesis techniques have already been scaled up to industrial production levels. Due to the high surface area and surface activity, nanoparticles have the tendency to aggregate. The important technique to enhance the stability of nanoparticles in fluids is the use of surfactants. However, the functionality of the surfactants under high temperature is also a big concern, especially for high-temperature applications.

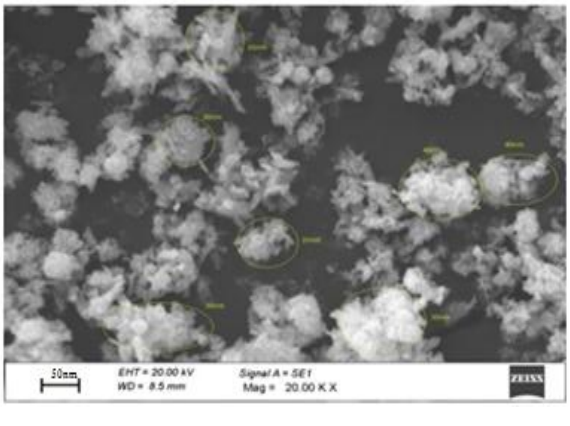


Fig. 1. SEM micrograph of CuO nanoparticles (the average diameter of CuO nanoparticles is about 50 nm).

The particle size was measured by Scanning Electron Microscope as shown in Fig.1. There are a few larger particles, which are likely aggregates of the smaller ones, but the whole distribution of the particles is relatively well dispersed. The particles are basically spherical or near spherical, the mean diameter is about 50 nm.

B. Solar Thermal Energy Experimental Apparatus

Fig. 2. The experimental apparatus.

The experimental apparatus is shown in fig. 2. In order to compare the efficiency of nanofluids with water in the same conditions, two same solar collectors were adopted. As can be seen from fig. 2. The area of solar collector is 2 m^2 and collector plates made of 9 copper riser tube inside diameter of 0.0125 m and 2 header pipe of 0.025m. The title angle of this flat-plate solar collector is 11^0.

C. Experimental Method

The tests have been performed from 11.00 to 14.00 hrs. Inlet and outlet temperature and pressure drop for different mass flow rate 0.016, 0.033, 0.05 b kg/s is noted. The heat gain of fluids can be calculated by using Eq. (1).

$$Q = m^0Cp\ (T_0\text{-}T_1) \qquad (1)$$

Where, Q is the heat gain of fluids, w; m^0 is the mass flow rate, kg/s; C_p is the heat capacity of water or nanofluid, J/ (kg K); T_o is the outlet fluid temperature, ^{0}C; T_1 is the inlet fluid temperature, ^{0}C.

The heat capacity of nanofluid can be calculated

$$C_{pnf}=C_{pnp\ \varphi}+C_{pw} \qquad (2)$$

where $C_{pnf,}$ $C_{pnp,}$ C_{pw} is the heat capacity of nanofluids, nanoparticle and water, respectively, J/(Kg K); $_{\varphi}$ is the volume fraction of CuO nanoparticle; The heat capacity of CuO and water is 390 J/(kg K) and 4182 J/(kg K), respectively.

Efficiency of solar flat plate collector

$$\eta =m^0C_p(T_0\text{-}T_1)/(AI) \qquad (3)$$

Where, A is area in m^2, I is the intensity of solar radiation in W/m^2.

III. RESULTS AND DISCUSSION

In order to investigate the performance of nanofluids as the working fluids in the solar collector system. The experiment was performed for mass flow rate of 0.016, 0.033, 0.05 Kg/s. The inlet fluid temperature is remaining unchanged. The outlet fluid temperature is the critical parameter. Outlet temperature and pressure drop is noted.

Below the graphical comparison between mass flow rate vs efficiency fig. 3, mass flow rate vs heat gain fig. 4, mass flow rate vs heat transfer coefficient fig. 5, mass flow rate vs nusselt number fig. 6 is shown in detail which gives a clear view for the result that is desired to be achieved.

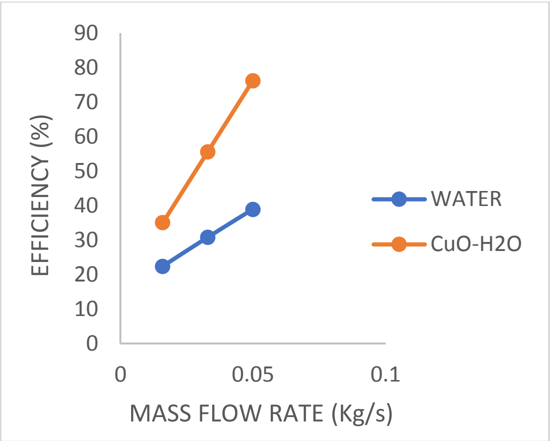
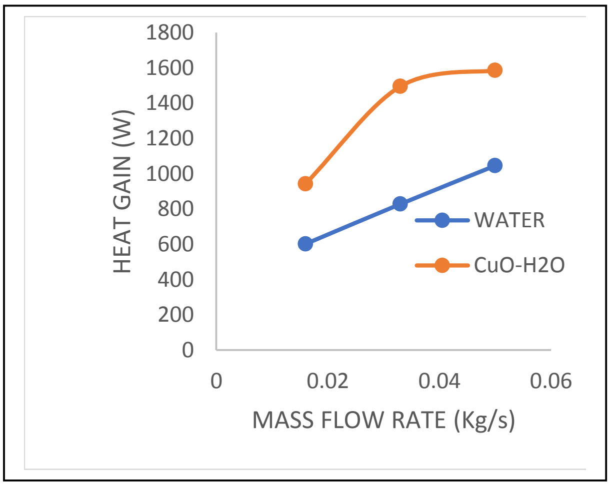


Fig. 3. Mass flow rate vs Efficiency, Shows that the efficiency of working fluid (CuO-H2O) is higher than the water as working fluid.



The fig.4. Mass flow rate vs heat gain, Shows that the heat gain character of working fluid (CuO-H2O) is more than the water as working fluid.

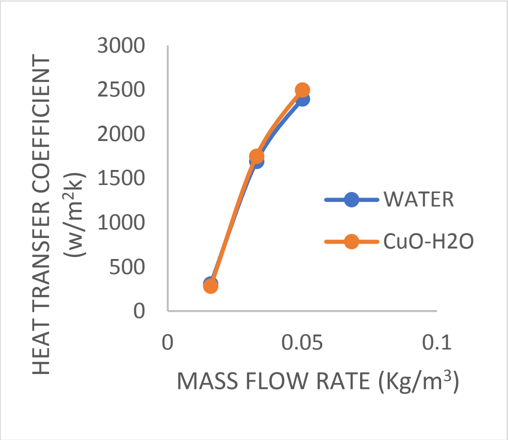


Fig. 5. Mass flow rate vs Heat transfer coefficient, Shows that the transfer coefficient character of working fluid (CuO-H2O) is increased than the water as working fluid.

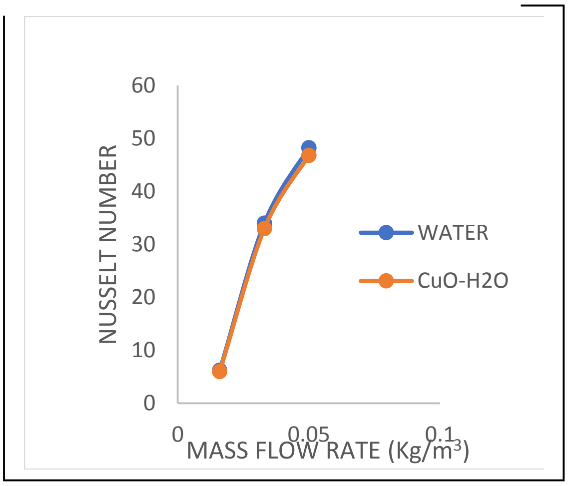


Fig. 6. Mass flow rate vs Nusselt number, Shows that the nusselt number of working fluid water (H2O) is more than the (CuO-H2O) as working fluid.

IV. CONCLUSION

Adding nanoparticle to water can increase the thermal conductivity of water. The heat transfer performance is increased. The efficiency of flat-plate solar collectorsis investigated separately for water and ($CuO-H_2O$) nanofluids as the working fluid for different mass flow rate. The experimental results show that their collecting efficiency increased by 36%, 38%, 34% for mass flow rate of 0.016, 0.033, 0.05 respectively when ($CuO-H_2O$) nanofluids is used as a working fluid compare to water.

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