Heat Transfer Enhancement of Solar Water Heater Using CNT/ H_2O Nanofluid

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Abstract:* *Solar energy is one oldest known form of non conventional energy. It can be used for electricity generation, heating water or air etc. In this paper solar energy is used to heat water in flat plate solar water heater. Water being working medium have limited heat absorbing capacity which can be greatly enhanced by using nanofluids. Nanofluid is the mixture of Nano sized material having high thermal conductivity and base fluid. Flow rate and Nano particle concentration were varied to understand their effect on the performance of water heater. Result shows that the highest efficiency of solar water heater with and without nanofluids were 81% and 66% respectively.

IndexTerms – Solar Energy, Solar Water Heater, Nanofluids, Efficiency.

1.INTRODUCTION

Solar energy is one of the most promising form on non conventional energy. Sun is a finite source of solar energy but it will give heat and light to earth for the next 5 billion years. As per the world energy assessment the solar energy can gives energy in the range of 1,500-50,000 Exa Joules (EJ).[1] This much energy can fulfill 4times the world's energy demand. Solar light spectrums have infrared as well as ultra violet rays. Throughout a year the sun gives around kWh/m2 in a day. With a few limitations like no energy in night solar energy is a promising source of energy. Solar energy gives heat as well as light. Energy packets in the form of photons can be used to generate electricity via PV module. Solar energy is used to heat fluids air and water. [2-4]Water heaters are commonly used for heating water. Air heating is used to maintain the temperature of air flowing inside a system. Solar energy is being used from drawing water from wells to desalination of water. The use of nanofluids is non conventional. Nanofluids can reduce the energy absorption rate and reduce wastage of energy.[5]

Nanofluids have revolutionized the area of heat transfer in various thermal systems. It is quite difficult to make changes in the existing thermal systems. Replacement of existing thermal system for the sake of efficiency increment is not viable. Nanofluids have given a new life to existing thermal systems by working as heat transfer agent.[6-7] Nanofluids can be mixed with base fluids running in these thermal systems. Various base fluids are being used like Ethylene glycol, synthetic oils, water etc. Nanofluids are basically a suspension of high thermal conductive nano sized materials and any base fluid. Lesser the size more will be its effectiveness. Nano particles can partially float or they will settle down in a mixture due to gravitational force. To increase the float time various techniques can be used like ultrasonication, by adding surfactant, magnetic stirring, etc. Ultrasonication can make float time to reach a remarkable 24-36 hours time scale, while surfactant followed by stirring can reach to 2-4 hours time scale.[8] There are so many surfactants in the market but Sodium dodecyl sulfate (SDS) and Triton X-100 are the most favorite between researchers. The mass flow rate, nanofluid concentration and solar irradiation play an important role in determining the efficiency of solar water heater. [9]Different nanofluids can be used to enhance the efficiency of water heater like Carbon Nano Tubes (Single wall and multi wall), Cupric Oxide, Titanium Dioxide, Aluminum Oxide, Zinc Oxide, Gold, Silver etc. Out of these Carbon nano tubes have highest thermal conductivity meaning it will greatly increase the heat absorbing capacity when added to the base fluid. [10].

In this study the effect of CNT/ H_2O nanofluid on heat transfer is analyzed. Flat plate solar water heater with forced circulation is taken for the study. This effect of mass flow rate, nano particle percentage and solar irradiance on heat transfer will be investigated.

2. EXPERIMENTAL

2.1 Materials

99% pure carbon nanoparticles having 15nm diameter were used. Triton X 100 was used as the mixing agent. Triton is highly used surfactant. Distilled water was used as the base fluid.

2.2 Nanofluid Preparation

Nanoparticles were weighed and 0.1, 0.2, 0.3% samples were made. MWCNT nanoparticles were mixed in base fluid and .0.2% triton X 100 by weight was used. The three were mixed and stirred using magnetic stirrer at 60^{o}C for 15 minutes. To ensure homogeneity ultrasonication was done at 20000Hz for 45 minutes.

2.3 Experimental Set-up

The experimental setup consists of water heater tilted at 23˚. The mixture is circulated in the system forcefully by a pump. Cylindrical rotameters were installed to measure regulate the flow rate. The changes in temperature from inlet to outlet were measured by using a data logger. To maintain the temperature of re-circulated water a heat exchanger is installed. Flow rate was regulated and kept in the range of 1-3 LPM. The nanoparticle concentration was kept beween.1-.3%.

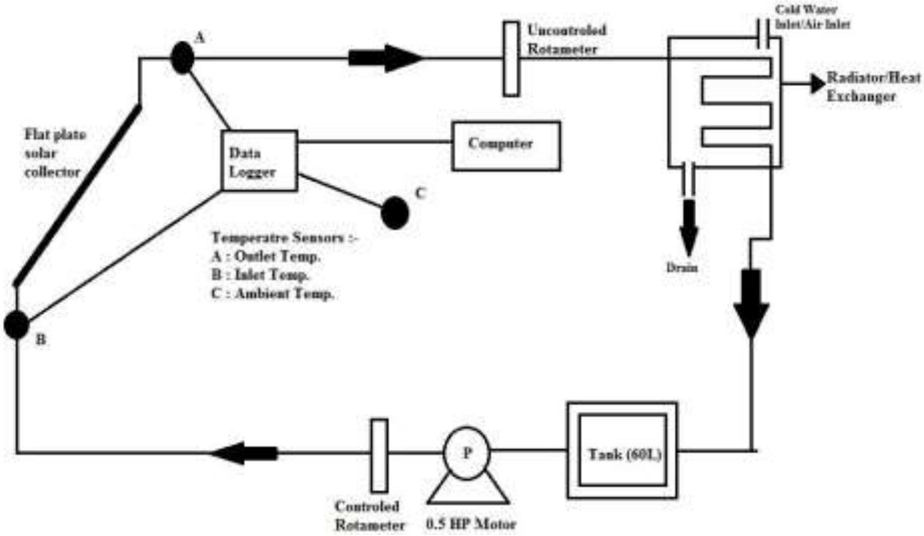

Fig 2.1: Line Diagram of the Experimental Setup

3.EFFICIENCY CALCULATION:

The useful energy can be calculated by

$$Q_u = mC_p(T_o - T_i) \quad (1)$$

The efficiency of the flat plate solar collector can be calculated by

$$Efficiency = \frac{Q_u}{Q_{in}} \quad (2)$$

$$Q_{in} = A_c G_T \quad (3)$$

The efficiency of the collector can be calculated by

$$Efficiency(\eta) = \frac{mC_p(T_o - T_i)}{A_c G_T} \quad (4)$$

4. RESULTS AND DISCUSSION

4.1 Trends and Observations

Readings of Inlet, outlet and ambient temperature along with solar irradiance (G_T) were plotted for 10:00 AM to 02:00 PM as shown in Figure 4.1.

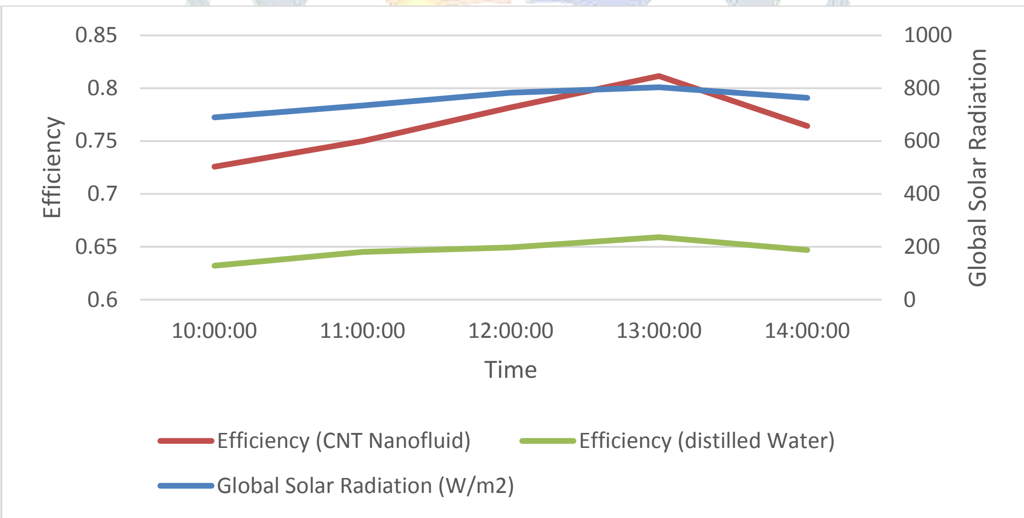

Figure 4.1: Efficiency vs global radiation vs time

The trends show that with the increase in solar radiation the outlet temperature increases and as a result efficiency increases. Maximum efficiency was achieved at 1PM.

4.2 Effect of Mass flow rate

Flow rate was varied from 1-3 LPM. The recorded values are shown in the form of figure 4.2 and 4.3

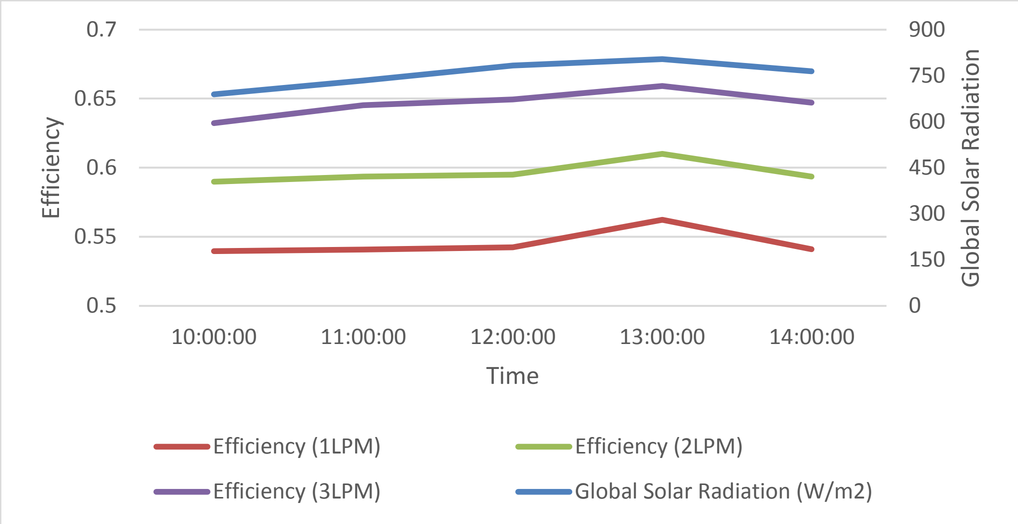

Figure 4.2: Efficiency of collector with water as working fluid versus global radiation versus time

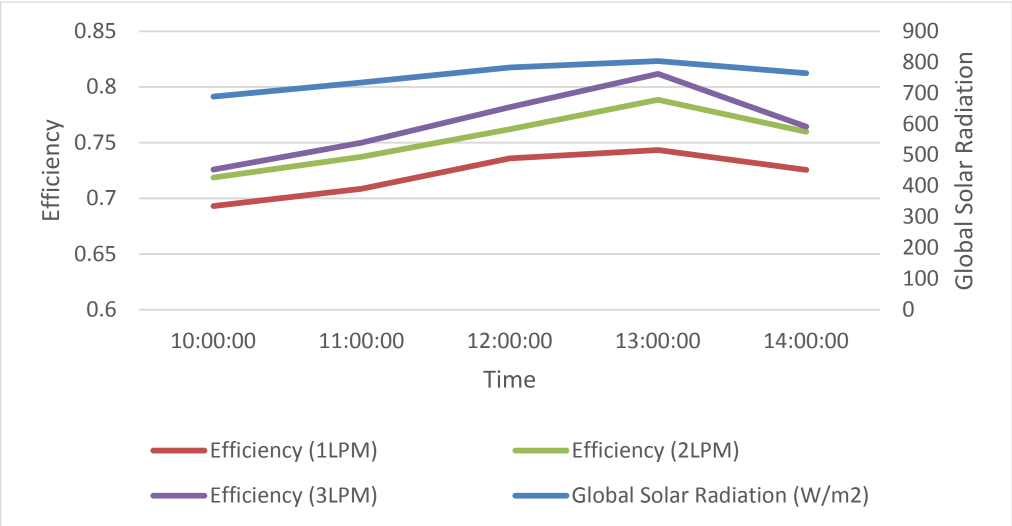

Figure 4.3: Efficiency of collector with MWCNT as working fluid versus global radiation versus time

As per Figure 4.2 and 4.3 the efficiency increase with the increase in mass flow rate and maximum efficiency was recorded at 3 LPM.

4.3 Effect of Reduced temperature gradient

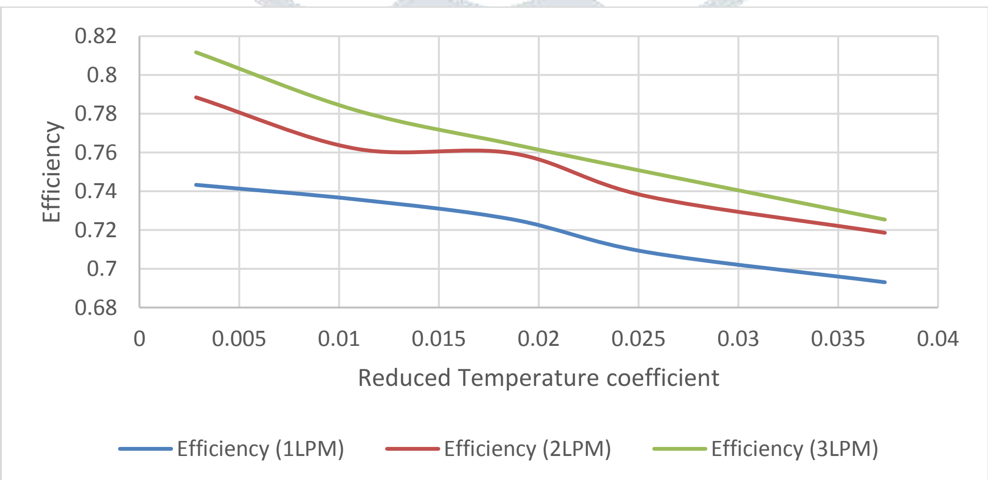

Figure 4.5: Efficiency versus Reduced temperature gradient for various volume levels of CNT/distilled water nanofluid.

The graph shows that efficiency increases with increase in reduced temperature gradient.

5. CONCLUSION

a. Highest efficiency for flat plate collector of both working fluid is obtained at 13:00 Hrs, about 66% for Distilled water and 81% for MW-CNT nanofluid (both at 3LPM)

b. From the above results we can also conclude that the efficiency of the flat plate collector depends on the global solar radiation proportionally.

c. The instantaneous efficiency of flat plate solar collector for both the working fluid; distilled water and CNT-Nanofluid; increases proportionally with the flow rate.

d. The increase in efficiency by using 0.3% CNT-nanofluid is about 31% higher than distilled water.

e. The maximum efficiency achieved by flat plate solar collector is 81% for MW-CNT at 3LPM.

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