IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e- ISSN: 2278-1684,p-ISSN: 2320-334X
PP. 86-91
www.iosrjournals.org

Experimental Investigation On Efficiency Of Flat Plate Solar Collector With BN/H_2O Nanofluid

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Abstract : *Solar Water Heating is an effective method of utilizing solar heat to perform many useful tasks. The energy from the sun can provide hot water for many applications, displacing the ssneed to burn fossil fuels. A solar collector is the main component for absorbing heat from solar beam and utilizing it for heating purposes. One way to absorb more heat from the solar beam is to modify heat characteristics of the working fluid. 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 substantial increase in liquid thermal conductivity, liquid viscosity, and heat transfer coefficient. Solar water heating is an effective method for heat demands in domestic applications. Solar collector is a main component of any solar water heating system. In this proposed work, the effect of BN–water nanofluid, as the working fluid (absorbing medium), on the performance and the efficiency of a flatplate solar collector is to be investigated experimentally.*
Key words:*Solar Water Heating, BN–water nanofluid*

I. Introduction

The many ways of increasing heat transfer through heat exchangers can be divided into two categories: Passive and active methods. Contrasts to active techniques, passive methods do not need an external force. Using nanofluids as heat transfer medium is a passive method for increasing heat transfer. In spite of many scientific works studying the effect of nanofluids application on thermal efficiency of heat exchangers, there exists very limited information about the study of nanofluids effect on flat-plate solar collectors. Das, Choi, Yu, and Pradeep expressed that the nanofluids could be utilized to enhance heat transfer from solar collectors to storage tanks and to increase the energy density. Natarajan and Sathish also believed the novel approach of increasing the efficiency of solar water heater through the introduction of nanofluids instead of conventional heat transfer fluids The aim of the current experimental work is to investigate the effect of using particular nanofluid, BN– H2O, as an absorbing medium (the working fluid) on the efficiency of a flat-plate solar collector. A review of the literature shows that there is no work on the flat-plate solar collector performance using BN/water as the working fluid.

II. Literature Survey

Nanofluids are suspensions of metallic or nonmetallic nanoparticles in a base fluid; this term was introduced by Choi [1]. A substantial increase in liquid thermal conductivity, liquid viscosity, and heat transfer coefficient are the unique characteristics of nanofluids. It is well known that metals in solid phase have higher thermal conductivities than those of fluids [2]. For example, the thermal conductivity of copper at room temperature is about 700 times greater than that of water and about 3000 times greater than that of engine oil. The thermal conductivity of metallic liquids is much greater than that of nonmetallic liquids. Thus, fluids containing suspended metal particles are expected apparent enhanced thermal conductivities rather than pure fluids [3]. Masuda et al. [4] dispersed oxide nanoparticles (Al2O3 and TiO2 with 4.3 wt%) in liquid and showed that the thermal conductivity is increased by 32% and 11%, respectively. Grimm [5] dispersed aluminum particles (1–80 nm) in a fluid and claimed a 100% increase in the thermal conductivity of fluid for 0.5–10 wt%. Using the nanofluids in solar collectors has been subjected to a few recent studies. Yosefi et al. [6] investigated the effect of MWCNT as an absorbing medium on the efficiency of a flat-plate solar collector experimentally and reported 35% enhancement in the collector efficiency for 0.4 wt%. Also the same researchers [7] repeated the experiments with Al2O3–Water nanofluid and reported 28.3% enhancement in the collector efficiency for 0.2 wt%. Chaji et al. [8] used TiO2–Water nanofluid as a working fluid at a small flat plate solar collector and observed 15.7% enhancement in the collector efficiency (compared with pure water). Polvongsri and Kiatsiriroat [9] investigated the thermal enhancement of a flat plate solar collector with silver nanofluid. They concluded that using this nanofluid can improve thermal performance of flat plate collector compared with water especially at high inlet temperature. He et al. [10] investigated the light-heat conversion characteristics of two nanofluids, water–TiO2 and water–carbon nanotube (CNT), in a vacuum tube solar collector under sunny and cloudy weather conditions. The experimental results show very good light heat conversion characteristics of the CNT–H2O nanofluid with the weight concentration of 0.5%. Because of the better light-heat conversion characteristics of the CNT–H2O nanofluid compared to the TiO2–H2O nanofluid, the temperature of the CNT–H2O nanofluid is higher than that of the TiO2–H2O one. Lue et al. [11] examined thermal performance of an open thermo-siphon which uses Cuo– Water nanofluid for high-temperature evacuated tubular solar collectors. They showed that with optimal filling ratio 60% and optimal mass concentration 1.2%, evaporating heat transfer coefficients may increase by about 30% compared with those of pure water. Keshavarz and Razvarz [12] experimentally studied the effect of Al2O3/Water nanofluid on the efficiency enhancement of a heat pipe at different operating conditions. They concluded that the thermal efficiency of a heat pipe charged with nanofluids is higher than that of pure water as working fluid. Saidur et al. [13] also theoretically investigated the effect of using Al2O3/Water nanofluid onthe performance of direct solar collector. They showed that using nanofluids within 1.0% volume fraction gave a promising improvement on the direct solar collector performance. Sani et al. [14] introduced a new nanofluid, made from dispersing carbon nanohorn in ethylene glycol, for solar energy applications. Their results show that this nanofluid is useful for increasing the efficiency of solar thermal devices and costs reduction (in comparison with carbon-black nanofluid). Natarjan [15] investigated the thermal conductivity enhancement of a base fluid using carbon nanotube (CNT). According to their results, if these fluids are used as heat transport media, the efficiency of the conventional solar water heater will be increased. Tyagi et al. [16] studied the capability of using a non-concentrating direct absorption solar collector (DAC) theoretically and compared its performance with a conventional flat-plate collector. In their research, a nanofluid composed of water and aluminum nanoparticles, was used as the absorbing medium. According to their results, the efficiency of a DAC with nanofluid is up to 10% higher than that of a flat-plate collector. Otanicar [17] studied environmental and economical effects of using nanofluids to enhance the solar collector efficiency compared with conventional solar collectors.

III. Design And Development Of Experimental Setup

A schematic diagram of the experimental setup is as shown in Fig. 1. The solar collector performance is experimentally investigated in Pune. The working fluid is circulated through the collector by using an electrical pump. The solar system tank serves as a heat exchanger for absorbing the heat loaded from the collector and then delivering it to the cooling water. A heat exchanger is placed inside the tank to transfer heat load from the solar collector to the cooling water. A flow meter is installed on the pipe after the electric pump. A simple valve was also installed after the electric pump to control the working fluid mass flow rate. Two temperature sensors are used to measure the fluid temperature at the inlet and outlet of the solar collector. The ambient temperature is measured by a thermometer. The total radiations are measured with the help of radiation Pyranometer. Fig. 1: Schematic diagram of the experimental

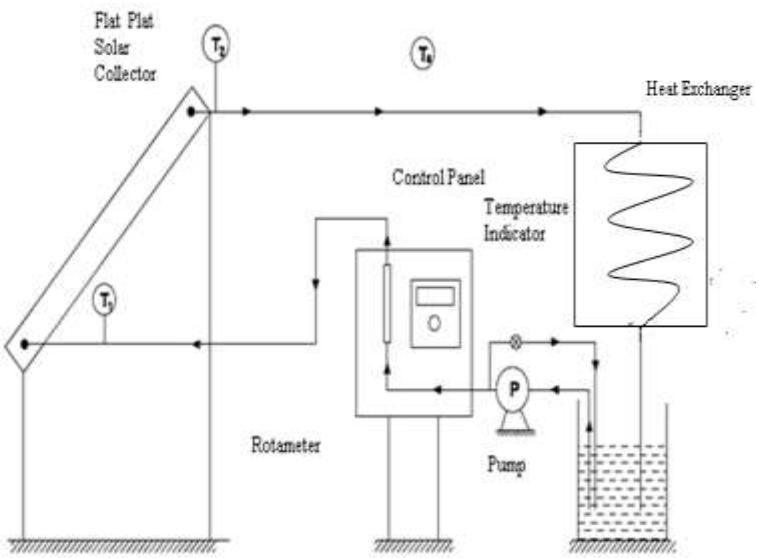
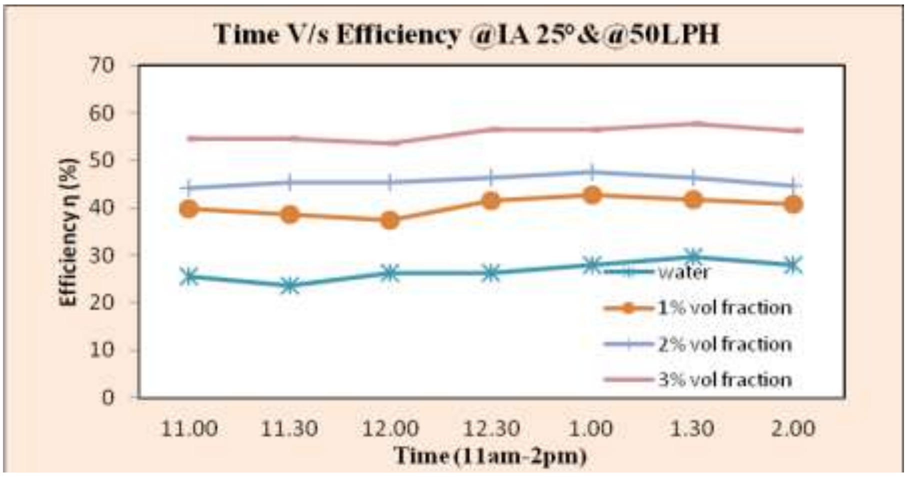


FIG 1

IV. Results And Discussion

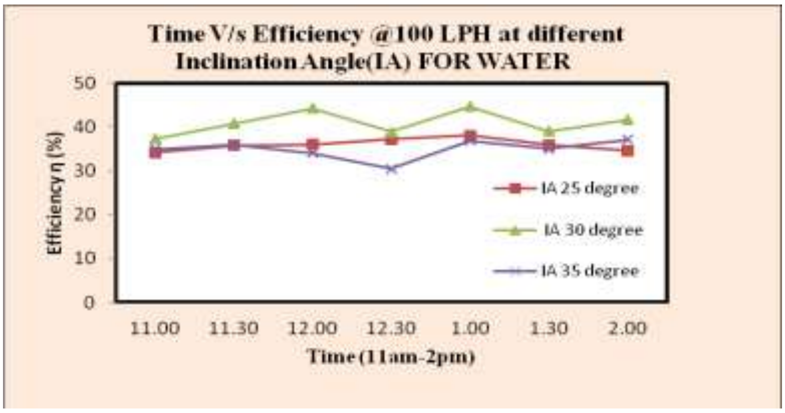
Variation of instantaneous collector efficiency with time for 25^0 inclination angles and mass flow rate of 0.01389 kg/sec.

Inclination angle 25° and flow rate 50 LPH				
Time	Instantaneous collector Efficiency (%)			
	Water	1% Vol Fraction	2% Vol Fraction	3% Vol Fraction
11.00	25.63113	39.87064	44.1425	54.46615
11.30	23.61586	38.58365	45.23601	54.5493
12.00	26.15896	37.41339	45.32192	53.53461
12.30	26.32624	41.58349	46.37008	56.54158
1.00	27.8468	42.79614	47.48613	56.57298
1.30	29.53188	41.7355	46.22475	57.73458
2.00	27.92482	40.86914	44.52568	56.1512



Variation of instantaneous collector efficiency with time for 25^0 inclination angle and mass flow rate of 0.01389 kg/sec.

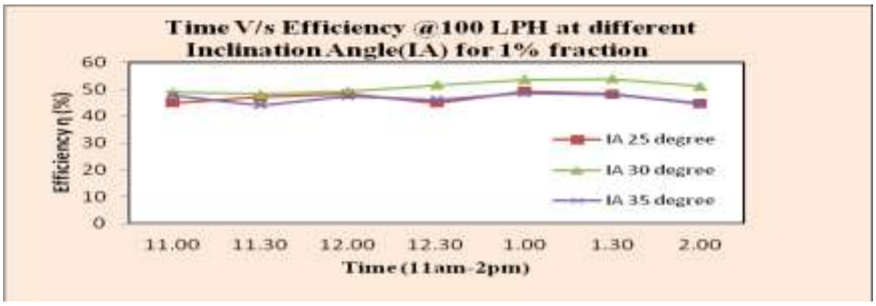
Water			
Time	Instantaneous collector Efficiency (%)		
	Inclination Angle(°)		
	25	30	35
11.00	34.1748	37.297	34.9296
11.30	35.8543	40.8287	36.0603
12.00	36.0056	44.3166	34.0675
12.30	37.1726	38.9311	30.546
1.00	38.0677	44.7354	36.9337
1.30	35.9255	39.0675	35.0511
2.00	34.63055	41.64194	37.14497



Variation of instantaneous collector efficiency with time at different inclination angle and mass flow rate of 0.02778 kg/sec for water

1% Volume Fraction			
Time	Instantaneous collector Efficiency(%)		
	Inclination Angle(°)		
	25	30	35
11.00	39.871	43.573	39.644
11.30	38.584	47.564	38.916
12.00	37.413	41.28	37.916
12.30	41.583	46.578	39.666
1.00	42.796	48.708	43.133
1.30	41.736	47.064	42.379
2.00	40.8691	49.7198	40.326

Variation of instantaneous collector efficiency with time at 0.02778kg/sec mass flow rate for different inclination angles for 1%Volume Fraction.



An experimental study has been carried out to investigate the efficiency of solar flat plate collector using BN/H_2O nanofluid. The volume concentration of BN/H_2O nanofluid has been varied from 1 % to 3 %. The performance of solar flat plate collector was evaluated at different inclination angle. The effete of mass flow rate on the performance of solar flat plate collector has also been investigated.

Following conclusions are made from the above mentioned experimental study and is detailed below:

- The collector efficiency of convectional flat plate solar collector can be improved by using BN/H_2O nanofluid as solar energy absorbing fluid. Which intern either enhances the instantaneous collector efficiency of convectional solar flat plate collector or reduces the collector area without compromising its thermal performance.
- Instantaneous collector efficiency for solar flat plate collector with BN/H_2O nanofluid enhances by 6-14% with variation in volume concentration from 1% to 3% as compared with water.
- The instantaneous collector efficiency of solar flat plate collector increases with increase in inclination angle from inclination angle 25^0 to 30^0 and reduces with increase in inclination angle from 30^0 to 35^0.
- Optimum Thermal performance of Solar flat plate collector for all formed tube used in the experimentation is obtained at 30^0.

- Thermal performance of flat plate solar collector increases with increase in intensity of solar radiation.
- With increase in mass flow rate of water and nanofluid the instantaneous collector efficiency of solar flat plate collector increases.

Thus the instantaneous collector efficiency of flat plate solar collector based water heater can be improved with the BN/H_2O nanofluid.

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