Comparative Investigation on the Performance of Flat Plate Solar Collector Using Different Nanofluids

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Abstract
Flat plate solar collector (FPSC) is one of the most popular equipment among solar energy systems which can be utilized for heating of domestic or public buildings. The performance flat plate solar collector depends on working fluid. In this work, performance of flat-plate solar collector investigated using different working fluids which include (Al2O3+Water) Nanofluid and water. Experiments performed at different mass flow rates (1kg/min, 2kg/min and 3kg/min) and also at different intensity (500 W/m^2, 1000 W/m^2, 1500 W/m^2). In results it has been observed that efficiency of collector has positive relation with mass flow rate and intensity. Useful gained by working fluids have positive relation with mass flow rate. Efficiency of collector is high for Nanofluids as compare to water as working fluids.

1 Introduction

For any country Economic from fossil fuel as like coal, petroleum and other sub-parts. The non-renewable energy reservoirs are getting exhausted with continuous utilization. So to complete this requirement there is only one beautiful way that is to use of solar energy in direct or indirect way.

Solar energy is most common energy which gives large amount of power. The source of solar energy is sun and 10^{16} watts are the energy which strike on earth surface Sun gives us 35 thousand times more power than we actually need**.** But of total solar energy reaching the earth's surface only 7 to 8% is being utilized**.** Energy comes from sun as electromagnetic wave which has wave length in between 0.2 to 0.4 micrometers. Solar radiation can divide one is direct radiation and other is diffuse radiation.

1) Flat plate solar collector

Flat plate solar collector comes under tube and plate type collector. It has flat absorber. Main components of liquid collector are tube, absorber, glass cover and casing and insulation. Typically, flat surface is made of copper, steel with thickness of 1mm to 2mm and the diameter of tube varies between 1 to 1.5 cm. Thickness of thermal insulation varies from 5-10 cm Solar radiation is stored by absorber surface then transfer that stored energy to tube in which working fluid flow. There is only one major difference between focusing collector and non-concentrating collector is that non-concentrating collector doesn't have reflecting or refracting surface.

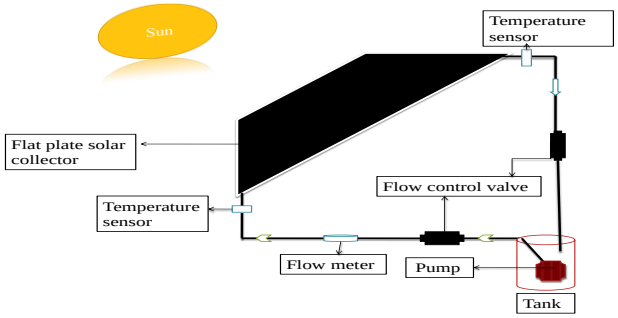

Figure 1 Flat plate solar collector

Veeraragavan et al., [1] presents an analytical model that investigated the influenced various factor like heat loss, particle loading, solar concentration and channel height on temperature profiles. They showed the temperature profiles at locations downstream of the inlet; in this the surface temperature became less than the bulk temperature which they considered an advantage of volumetric absorption.. Salavati et al., [2] conducted an experimental work to investigate the performance flat plate collector using SiO2/ethylene glycol (EG)–water Nanofluid at 1%.volume fraction and mass flow rate was varying from 0.018 to 0.045 kg/s. In result they showed that the collector performance had positive relation with concentration and also

showed efficiencies at 0.75% and 1% are very close. Karami et al., [3] conducted an experimental work to investigate the performance of domestic solar water heater. In this work, copper oxide nanoparticle was mixed 70 %water and30% ethylene glycol in mixture. Their thermo-physical and optical properties were presented. They showed that performance of collector had positive relation with volume fraction and flow rates and also they showed performance collector increased by 9–17%. Sarsam et al., [4] reviewed past year research work where an experiment conducted to find the performance of flat-plate solar collector. Nanofluid was used as working fluid. They also presented some conclusions and recommendations about the application nanofluids in flat-plate collectors. Michael et al., [5] presented an experimental work to find performance of flat plate solar collector where CuO/water Nanofluid was used as working fluid with volume fraction 0.05%. And volume flow rate was 100 Liters per Day (LPD). In result section theoretically and experimentally results of nanoparticle and Nanofluid were compared. Colangelo et al., [6]presented an experimental work to find performance of flat plate solar collector where they used distillated water and Al2O3–distillated water as working fluid and Concentration of Nanofluid was (3.0%) for this research work. Results showed that thermal efficiency increased up to 11.7% for Nanofluid as compared water as working fluid. Bozorgan et al., [7] reviewed the applications of Nanofluid in solar thermal engineering system and solar thermal system's design. Also future work was discussed in this research paper. Kumar et al., [8] conducted an experimental work to find out the efficiency of direct absorption solar collector with area 1.4 m2 where Al2O3-H2O was used as working fluid at three flow rates of 1.5, 2 and 2.5 lpm. And volume fraction was 0.005%. In result they showed Collector' efficiency was increased by 8.1% and 4.2% for 1.5 and 2 lpm flow rate. Sandesh et al., [9] conducted an experimental work to find out the thermal performance of wickless heat pipe solar collector where CNT–water Nanofluid was working fluid. Diameter Carbon nanotubes (CNT) nanoparticles with diameter 10–12 nm and 0.1–10 m length was used. The effects of various filling ratio (F.R.) (50%, 60%, and 70%) and coolant flow rate on thermal performance were discussed in this study.

Kasaeian el at., [10] reviewed different types of solar collectors, photovoltaic systems and solar thermo electrics where Nanofluid was working fluid. And they also included different process to reduce manufacturing cost of nanoparticle like fusing at low temperature process.

He et al., [11] conducted an experimental work to find out the performance of flat plate collector. Experiments were conducted on different mass flow rate and their sizes were also different. Cu-H2O Nanofluid was used as working fluid.140L/h was the Mass flow rate on which all the experiments were performed. They found that solar collector's performance had negative relation with nanoparticle size because when size of nanoparticle increased the collector performance was dropped.

2 Experimental setup and its components

It has been observed from the literature review of flat plate solar collector using Nanofluid as working fluid that by using Nanofluid as working fluid enhances the performance of flat plate solar collector. And also increases the heat transfer rate between fluid and plate of solar collector.

Equipment Information

There are many types of equipments used in this experimental work.

- Flat plate solar collector
- Water flow sensor
- Temperature sensor
- Instrument for solar radiation
- Instrument for Nanofluid preparation

Flat plate solar collector

For examine the efficiency, flat plate solar collector is used in this experimental work. Flat plate solar collector comes under tube and plate type collector. The work of solar collector is to collect solar energy. That heat energy is useful for many works. There is different type of material is used in bases of their work. For example aluminum is used in absorber.

Different components of flat plate solar collector

1) Header pipe
2) Riser tube

3) Absorber plate
4) Casing
5) Insulation
6) Glass cover

Figure Header pipe

Figure Flat plate solar collector

3 Results and discussion

The formulas needed to calculate the Efficiency of flat plate solar collector, useful energy gain, reduce temperature parameter and specific heats of nanofluids have been given below.

Efficiency of flat solar collector

Thermal efficiency of the collector is the ratio of the useful heat gain to the total input energy.

$$\eta = \frac{\dot{m}c_p(T_{out} - T_{in})}{IA_c}$$

Cp (Nanofluid) =Cp (volume fraction of nanoparticle) +Cp (1-volume fraction of nanoparticle)

Useful heat gain

Useful energy gain is calculated by using temperature difference, specific heat and mass flow rate.

$Q_u = \dot{m}c_p(T_{out} - T_{in})$

NOMENCLATURE

Q –Heat transfer rate

C_p- Specific heat

ṁ- Mass flow rate

I- Intensity

A_c- Area of collector

T_{in}- Inlet temperature of fluid

T_{out}- Outlet temperature of fluid

Various types of graphical correlations have been produced to compare the efficiency of flat plate solar collector for different working. By graphical representation we checked the effect of various parameters like mass flow rate, Intensity on the efficiency of flat solar collector and useful energy gain by working fluids

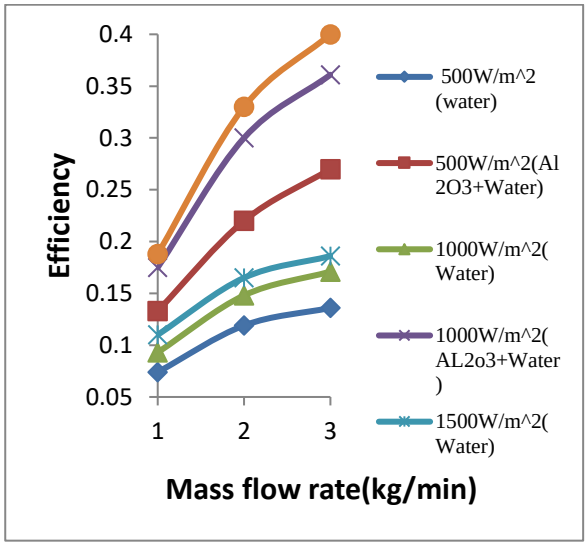

Figure Collector efficiency versus mass flow rate for different fluids

In figure shows correlations between collector efficiency and mass flow rate for different working fluids. Experiment conducted for two different working fluids which are water and (Al2O3+Water) Nanofluid. As shown in figure that as mass flow rate increases the value of efficiency also increases. Efficiency of collector calculated at different mass flow rates (1kg/min, 2kg/min and 3kg/min). As shown in figure at 3kg/min mass flow rate, efficiency of collector is high for water. Same thing goes for (Al2O3+Water) Nanofluid. Efficiency of collector is high for (Al2O3+Water) Nanofluid as compare to water as working fluid.

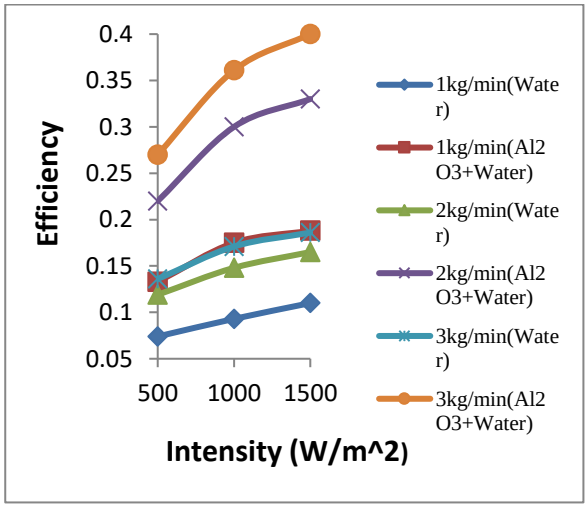

Figure Collector efficiency versus Intensity for different fluids

In figure shows correlations between collector efficiency and intensity for different fluids. As shown in figure that as intensity increases the value of efficiency also increases. Efficiency of collector calculated at different intensity (500 W/m^2, 1000 W/m^2, 1500 W/m^2).As shown in figure at1500W/m^2 intensity, the efficiency of collector is high as compare to other intensity for water. Same thing goes for (Al2O3+Water) Nanofluid. Efficiency of collector is high for (Al2O3+Water) Nanofluid as compare to water as working fluid.

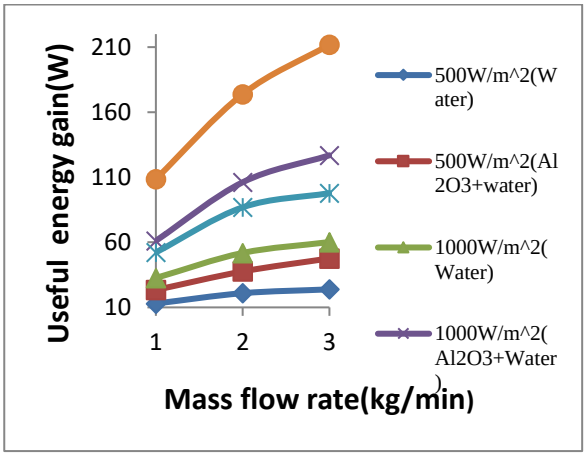

Figure Useful energy gain versus different mass flow for different fluids

In figure show correlations between Useful energy gain (W) and mass flow rate for different fluid. As shown in figure 34 that as mass flow rate increases the value of Useful energy gain (W) also increases. Experiment conducted for two different working fluids which are water and (Al2O3+Water)Nanofluid. Useful energy gain (W) calculated at different mass flow rates (1kg/min, 2kg/min and 3kg/min)and at different intensity(500 W/m^2, 1000 W/m^2, 1500 W/m^2).As shown in figure at mass flow rate 3 kg/min,useful energy gain (W) by working fluid is high as compare to other mass flow rate of water Same thing goes for (Al2O3+Water) Nanofluid. Useful energy gain (W) by working fluid is high for (Al2O3+Water) Nanofluid as compare to water at all mass flow rate.

4 Conclusions

The aim of doing the research on this field is to improve the efficiency of collector having flat absorber area. Experimental study is to be done on flat plate solar collector for different working fluids at different mass flow rate and at different intensity. This research also compared different parameter like efficiency versus mass flow rate, efficiency versus intensity and useful energy gain versus mass flow rate in graphical representation. Based on this experimental investigation on flat plate solar collector using different fluid following conclusions are achieved

a) Experiment conducted for two different working fluids which include Al2O3+Water Nanofluid and Water. It has been observed that the value of efficiency of collector increases with mass flow rate for all working fluids. Where mass was varying from 1kg/min to 3kg/min. At mass flow rate 3 kg/min efficiency of collector is high as compare to other mass flow rate for all working fluid. Efficiency of collector is high for Nanofluids as compare to water as working fluids.

b) Experiment conducted for two different working fluids which include Al2O3+Water Nanofluid and Water. It has been observed that the value of efficiency of collector increases with intensity for all working fluids. Where the intensity was varying from 500 to 1500W/m^2. At intensity 1500W/m^2, efficiency of collector is high as compare to other intensity for all working fluids. Efficiency of collector is high for Nanofluid as compare to water as working fluids.

c) Experiment conducted for two different working fluids which include Al2O3+Water Nanofluid and Water. It has been observed that the value of Useful energy gain (W) increases with mass flow rate for all working fluids. Useful energy gain (W) calculated at different mass flow rate which is varying from 1kg/min to 3kg/min. At mass flow rate 3 kg/min, flow rate for all working fluids.

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