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Design and Analysis of Modified Solar System using Sio_2 Nano Fluid

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***Abstract*: The energy conversion efficiency of a conventional close-loop solar system is too low as compared to the solar radiation available. In this case a large amount of the incoming solar energy is either reflected or absorbed as heat energy. It is expected that the efficiency of conversion is improved by using Nano-fluids within the flat plate solar collector system. In this study, we made an attempt to design and study the effect of using different concentration of Nano particle concentration in water as base fluid. Nano particles of SiO2 is used to see its effect on heat transfer in the system as compared to conventional water based close-loop solar water system. It has been studied that the thermal efficiency of solar flat plate collector can be improved by using Nano fluids in the water base fluid. The major contribution of the present work is to design and analyze the effect of adding the Nano particles in the water base on the thermal efficiency of the solar water heaters.**

Keywords: Flat Plate solar collector, Solar Radiation, Nanofluid, SiO_2, Heat Transfer

1. INTRODUCTION

To date, fossil fuels are wont to supply the bulk of our energy demand, as these are less expensive and more feasible than energy sources. On the opposite hand, their negative impact on the environment has been a serious concern, which has led scientists to look for energy sources, like solar power. It has been found that solar power is superior to fossil fuels because solar power is cleaner and doesn't cause any environmental pollution. Therefore, solar power has become a widely used energy source. Till now, many researchers have examined the efficiency of solar collectors. The efficiency of the flat plate solar collector depends on many factors, including the position of the sun, weather, the orientation and therefore the angle of the panel, the fabric composition and mounting structure of the panel, the mass flow, and therefore the sort of working fluid.

A solar hot-water heater may be a system that utilizes solar power (or the energy from sunlight) to heat water. It has a system that's installed on a terrace or open space where it can get sunlight and therefore the energy from the sun is then wont to heat water and store it in an insulated tank. The system isn't connected to electricity supply and thus doesn't have a toggle switch, but it uses the daylight throughout the day to heat the water and store it in the storage tank. Water from the tank can then be used for any application as desired.

There are 2 types of solar water heaters:

FPC (Flat Plate Collectors) system: Flat Plate Collector Systems are metallic systems. They contain an insulated metallic box covered with a toughened glass. The metallic box features a layer of a copper sheet which is sweet for absorbing heat. The copper sheet is further coated with a black coating which improves heat absorption.

ETC (Evacuated Tube Collectors) system: Evacuated Tube Collector systems are made from Glass. It has vertical tubes that are made out of two co-axial glass tubes. The air between the 2 coaxial tubes is removed to make a vacuum which improves insulation.

There are two sorts of solar water heating plant.

Open loop Solar water heating system: It is the simplest and typically the Least Expensive system to install. There is no device which allows efficient heat transfer on to the water.

Close loop Solar water heating system: Pumps circulate a non-toxic, heat transfer fluid through the collector and a heat exchanger. They are popular in climate is prone to consistent freezing temperature.

Heat exchanger is a piece of equipment Built for efficiency transfer from one medium to another. The means of heat exchanger is that to transfer the head between flowing fluids. The heat exchanger is device that used for transfer of internal thermal energy between two or more fluids at different temperature. In most heat exchangers, the fluids are separated by a heat transfer Surface, and ideally, they are doing not mix.

Nano fluids are defined as fluids with Nano sized solid particles suspended in Base fluid. Nano-fluids are the new generation heat transfer fluids for various industrial and automotive applications because of their excellent thermal performance. The Nano fluids on the opposite hand offer many advantages over the only phase pure fluids and suspensions with micro particle. The problem of particle sedimentation due to gravity, clogging of micro channel passage, and erosion of tube material are minimized to a great extent when Nano fluids are used in heat exchangers.

2. REVIEW OF LITERARURE

Most of the literature studies available on enhancement in heat transfer rate have been carried out experimentally, by using Nano fluids of SiO_2. with water or ethylene glycol as base fluid. Enhancement of heat transfer rate has been studies under different conditions like at different volume concentration on Nano fluid, for different flow rate of Nano fluid, for different particle size of Nano fluid.

Choi SUS etal , did extensive work on enhancing thermal conductivity of fluids with Nanoparticles. their results very well agree with the results of other investigators. they have chosen the Nano particle size in the range of 100-150 Nano. They

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concluded that decreasing the Nano range below 100 has very little improvement in thermal efficiency.

Wong KV etal, worked on Applications of Nano fluids and reviewed the current and future applications of Nano fluids with special reference to solar heat energy.

Ho CD etal, worked on recycle effect on the collector efficiency improvement of double-pass sheet-and-tube solar water heaters with external recycle, and applied their results in the area of solar water heaters and concluded that the thermal efficiency of solar water heaters improved considerably.

Xie H etal, conducted experiments to evaluate the dependence of thermal conductivity of Nanoparticle-fluid mixture on the base fluid and concluded that the thermal conductivity increases with the decrease of Nano range

Y. Raja Sekhara,*, K.V.Sharmab, R.Thundil Karupparaja, C.Chiranjeevi studied "Heat Transfer Enhancement with Al2O3 Nano fluids and Twisted Tapes in a Pipe for Solar Thermal Applications". In this paper, Heat transfer experiments were conducted in a pipe under low Reynolds number range using water and water based Nano fluids. Heat transfer coefficient and friction factor for Nano fluid in the flow path enhanced compared to water. The experimental data is compared with the data of literature and are found to be in good agreement. The increase in heat transfer coefficient in plain tube with use of Nano fluids is greater by 8-12% compared to the flow of water in a plain tube. The Nano fluid of 0.5% particle concentration is having highest friction factor compared to water.

Lazarus Godson Asirvatham, experimental study is carried out to investigate the heat transfer characteristics of silver/water Nano fluid in a solar flat plate collector. The solar radiation heat flux varies between 800 W/M2 and 1000W/ M2, and the particle concentration varies between 0.01%, 0.03%, and 0.04%. The fluid Reynolds number varies from 5000 to 25000. The influence of radiation heat flux, mass flow rate of Nano fluid, inlet temperature into the solar collector, and volume concentration of the particle on the convective heat transfer coefficient and the collector efficiency are studied.

Jee Joe Michael, S. Iniyan (2) Flat plate solar water heater is widely used for heating of water in low-temperature residential applications. In this paper, Copper Oxide/water (CuO/H2O) Nano fluid is prepared from Copper Acetate and its thermal performance was investigated experimentally on a 100 Litters per Day (LPD) thermo syphon based indirect- type flat plate solar water heater.

Yousefi et al. studied Al2O3 Nanofluid (with and without surfactant) as a working fluid in a flat plate solar collector. Triton X-100 was used as a surfactant, and Al2O3 Nanofluids were tested in terms of their Nanoparticle concentration at two different weight fractions: 0.2% and 0.4%. During the test periods, the mass flow rate was stabilized at three different rates: 1 L/min, 2 L/min, and 3 L/min, in order. The ASHRAE 93-2010 standard was used to calculate the efficiency. The results demonstrated that the efficiency of the solar collector compared to water as a working fluid was enhanced by 28.3% when using a 0.2 wt % Al2O3 Nanofluid. The maximum increase in efficiency was 15.63% when using the surfactant.

3. METHODOLOGY

A Solar system were designed and constructed. Initially water was used as a heat absorbing medium. The fluid was loaded into the system by a pump.

Inlet and outlet temperature of the working fluid, temperature of the plate, and ambient temperature were measured by using k-type thermocouple (having temperature range 0oC to 1000oC). Temperature was displayed on Digital Temperature Display (DTI) which shows the temperature in degree Celsius. Solar radiation was calculated by using parameters like angle of tilt, altitude and latitude of location, etc as per the standard parameters from different professional and international sites and local atmosphere sites.

The readings/data is recorded after 2 hours. The readings were taken during a span of every week. Best readings were picked. The experimental result contains the performance of solar collector using water, SiO2 Nano fluid of concentration 0.3g as well as 0.6g in 6 liters of base fluid (water). The flow rate is kept constant in every performance done. The flow rate was kept 60 LPH. After the readings noted, calculations were done

4. MATERIAL USED

Parts	Material Used
Flat Plate Collector	
Absorber plate	Copper
Header & Small pipes	Copper
Glass cover	Toughen Glass
Insulating material	Glass Wool
Heat Exchanger	
Tubes	Copper
Storage tank	
Inner Tank	Aluminum
Insulating material	Glass Wool
Outer tank cover	Aluminum
Thermocouple	
Type	K-type
Range	73k-623k
Nanoparticle	
Type	Silica Oxide
Thermal conductivity	35W/mK-37W/mK
Specific heat	730J/KgK
Molecular weight	60.08g/mol

Table 1. Material selection

5. SCHMETIC DIAGRAM

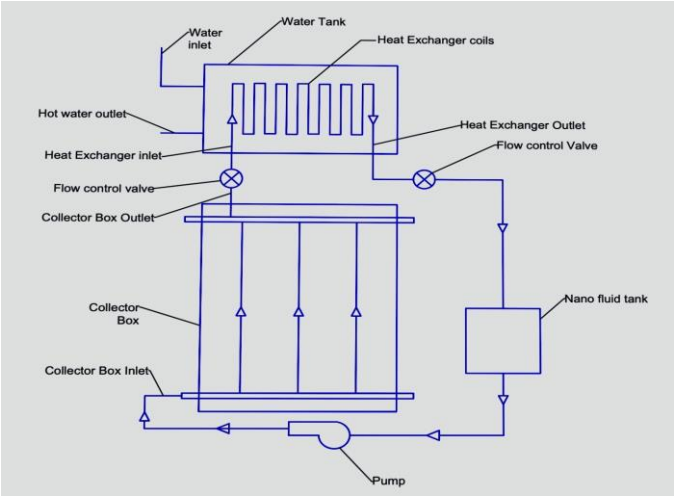

Fig 1. Schematic diagram of model

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6. EXPERIMENTAL SETUP

Fig 2. Pictorial view of model

The experimental setup consists of a flat plate collector box, Storage tank, Heat exchanger. The assembly of the Model is done as per the schematic diagram (fig 1). The collector box and the storage tanks are insulated by using glass wool. The heat exchanger is inside the storage tank. The tank consists of inner tank and outer tank. Between the both tank insulation is provided. The Nano fluid tank is placed below the collector box and a storage tank is placed above the collector box. The Nano fluid is supplied throughout the tubes by using pump. Forced circulation method is used to supply the working fluid in the system. Different concentration of Nano fluid i.e. 0.3g &.06g is used at a constant flow rate. The Pictorial view of model is shown above (Fig 2).

7. IMPORTANT FORMULAS

1. Mass Concentration **(Φ_M)** –

$$\Phi_m = (\text{mole/ total solution volume}) \times 100$$

2. Volume concentration (Φ_V) –

$$\Phi_V = (1/(100/\Phi m)(\rho n/\rho f) + 1) \times 100$$

3. Heat capacity of Nanofluid ($c_{p,nf}$)-

$$c_{p,nf} = \Phi_V c_{p,n} + (1 - \Phi_V) c_{p,f}$$

4. Useful energy (Q)-

$$Q = \dot{m} C_{p,nf} \Delta T$$

5. Overall efficiency (η)-

$$\eta = (Q/A G_T) \times 100$$

where,
Φ_m= mass concentration
Φ_V= volume concentration
$c_{p,nf}$ = specific heat of nanofluid
$c_{p,n}$ = specific heat of nano particle
$c_{p,f}$ = specific heat of base fluid
$\dot{m}$ = mass flow rate
A= area of collector
G_T = solar radiation

8. RESULT AND DISCUSSION

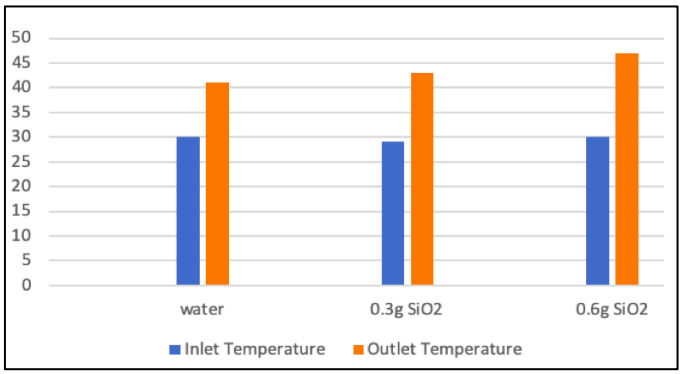

Fig 3 Graph showing inlet temp. and outlet temp. by using different working fluid and their concentration.

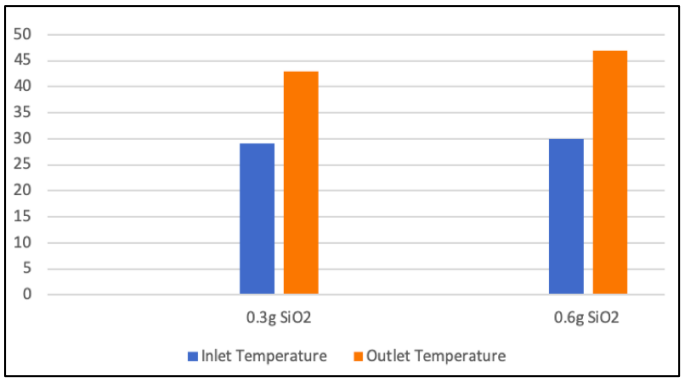

Fig 4. Graph showing inlet temp. and outlet temp. by using different concentration of Nano fluid

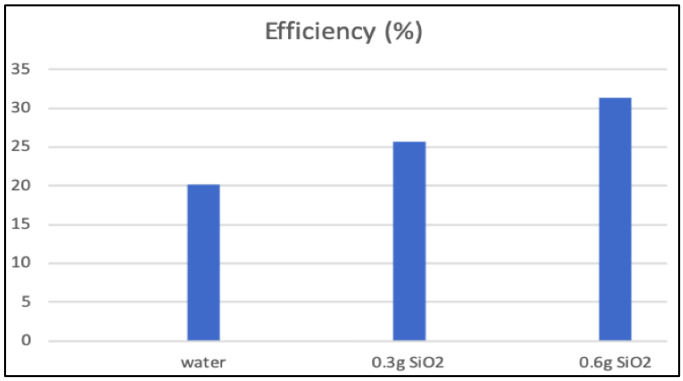

Fig 5. Heat transfer obtained by using different working fluid.

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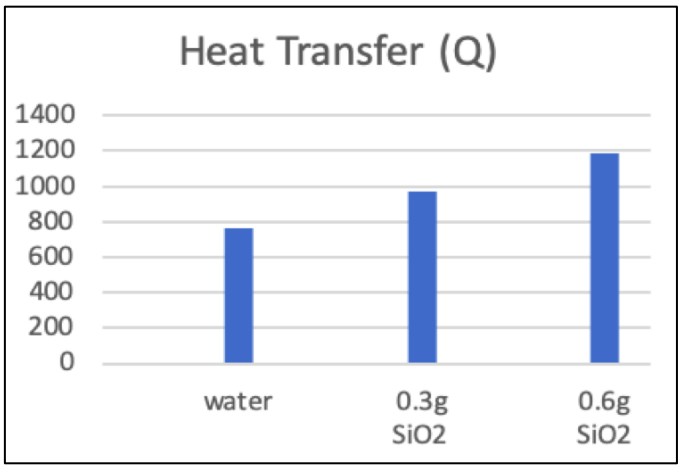

Fig 6. Efficiency obtained by using different working fluid

It is observed that using Nano fluid in conventional closed loop solar water heater provides more efficiency as compared to conventional mode. The 0.3g concentration provides 5.5% efficiency and 0.6% concentration provides 11.2% efficiency more than the conventional solar water heater.

9. CONCLUSION

Till now, many researches have increased the efficiency of solar collector. But still its efficiency is less as compare to the conventional technologies. using Nano fluid as a heat absorbing medium can make improvement in thermal conductivity and heat transfer inside the system. It is observed that the adding and increasing the Nano particle in working fluid increases efficiency of the solar collector. By using 0.3g of SiO_2 and 0.6g in 6l SiO_2 of base fluid increased 5.5% and 11.2% efficiency respectively.
The large increase in the efficiency is observed by using the flow rate of 60LPH.

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