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A STUDY ON USE OF NANO FLUIDS IN SOLAR COLLECTOR

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ABSTRACT
Nano fluids are developing fluids which exhibit the thermal properties superior than the conventional fluid . The use of nano fluid in solar collector to increase the thermal efficiency as well as heat transfer rate, thermal property cooling rate, etc. It was found that the use of the nanofluid in the solar collector field can play a crucial role in increasing the efficiency of the solar devices. Nanofluid an advanced type of fluid containing small quantity of nanoparticles (less than 10^2 nm), has been proven to provide more efficient heat transfer compared to conventional fluids. The dispersion of a little amount of solid nanoparticles in traditional fluids such as water or ethylene glycol changes their thermal conductivity noticeable. Based on comprehensive works, it has been also realized that the thermal properties of nanofluid such as thermal. Nanofluids are the fluid that has shown various improvements in the thermal properties over the previous decades. In the field of nanotechnology, nano fluids have a great prospective to enhance the rheological properties like thermal conductivity of base fluid like water, ethanol etc.

Keywords: *Nano fluid, rheological, thermal.*

I. INTRODUCTION

The current power generation method from fossil fuels such as oil or coal is damaging our environment. For example, nuclear power stations to generate electricity are an unacceptable risk in most locations. Therefore, we need to diversify from this non- renewable energy sources and look for alternatives. One of the most promising renewable energy sources available is solar energy since it is freely available, abundant and has minimum ecological impact.

In order to harness the solar energy efficiently Nanofluids are used, now what are Nanofluids?Nanofluid or mixture of nanoparticles in fluids is defined as homogeneous mixture of a base fluid such as (water, oil, ethylene glycol and molten salts) with a very little quantity of solid metallic or metallic oxide nanoparticles or nanotubes .Nanofluids have good properties of radiation absorption and it has a high thermal conductivity. For example, the thermal conductivity of individual multi-walled carbon nanotubes (MWCNTs)at the room temperature were found to have values more than 3000 W/m K.

In direction to increase the effectiveness or performance of solar collectors, one of the most appropriate and efficient methods is to change the working fluid like water, ethylene glycol by greater thermal conductivity fluids like aluminum oxide, copper oxide. The blend of base fluids like water or ethylene glycol with suitable nanoparticles like silicon oxide or aluminum oxide is called nanofluids. The thermo substantial properties of nanofluids are mainly depending on the working temperature.

A. Solar collector
A solar collector is a device which collects the solar radiation from the Sun light. These are primarily used for solar heating and allow for the heating of water for uses. These collectors are generally installed on the roof and must be very sturdy as they are exposed to a variety of different weather conditions.

1. Function of solar collector
1. Asper the name suggests solar collector collects the solar energy which are incident on it.

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2.Therefore, the main function of the solar collector is to collects the solar energy and transferswith fluid passing in contact with it.

B. Nano fluids

Ananofluid is aconsist of nanometer-sized particles, called nanoparticles. These fluids are engineered dispersed mixture of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, non-metals, oxides, carbides, or carbon nanotubes.Common base fluids include water, ethylene glycol and oil.Nanofluid have a good intensity of radiation and it have a high thermal conductivity. The size of nanoparticles is very small and in the range of 1–100 nm which is about one-thousandth the diameter of a human hair.

1. Classification of nano fluid

Nanofluids can be generally classified into two categories metallic and non-metallic. Eastman et al, theoretically studied the atomic and microscale-level characteristic behavior of nanofluids. The result shows that the increasing of thermal conductivity, temperature effects and significant raise in critical heat flux. Metallic nanofluids many times refer to those containing metallic nanoparticles such as (Cu, Al, Zn, Ni, Si, Fe, Ti, Au and Ag), while nanofluids contains non-metallic nanoparticles such as aluminium oxide (Al2O3), copper oxide (CuO) and silicon carbide (SiC, ZnOTiO2) are many time considered as a non-metallic nanofluids, semiconductors (TiO2), Carbon Nanotubes (SWCNT, DWCNT and MWCNT) and composites materials such as nanoparticles core polymer shell composites[13]. In extention of new materials and structure are attractive for use in nanofluids where the particle liquid interface is dazed with various molecules.

2.Thermal conductivity of nanofluids

The thermal conductivity of solids is greater than liquids. Generally fluids are used in heat transfer applications like water, ethylene glycol and engine oil having low thermal conductivity when it compared to thermal conductivity of solids, specially metals. So, addition of solid particles in a fluid can increases the conductivity of liquids. But we cannot add large solid particles due to some problems:

- Mixtures of partical are unstable and hence, sludge occurs.
- Due to presence of large solid particles can require large pumping power and hence it increase in cost.
- Solid particles may be wear the channel walls[1].

Due to these drawbacks, usage of solid particles are not practically possible. Recently improve in nanotechnology made to possible small solid particles with smaller than 10 nm in diameter. Liquids, which obtained higher thermal conductivity and are known as Nanofluids. As can be clearly seen from figure that carbon nanotubes have highest thermal conductivity as compared to other materials[2].

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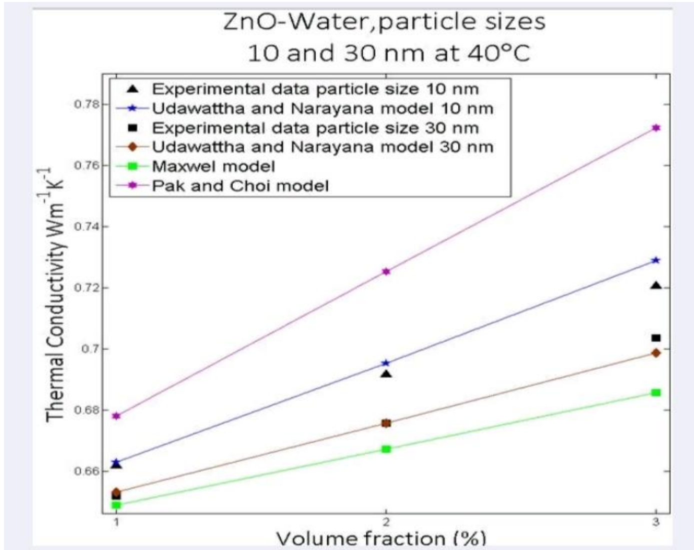

FIG: 1 ZnO-water, particle size 10 and 30 nm at 40^o c[1]

3.viscocity

viscosity is one of the parameter under studying for determine the characteristics of nanofluid. The SiO2 nanofluid was investigated and reported that its viscosity depends on the volume fraction. Another set of researchers studied commercial engine coolants dispersed with alumina particles. They founded the nanofluid prepared with evaluated amount of oleic acid (surfactant) was tested to be stable. While the pure base fluid displays Newtonian over the measured temperature, it transforms to a non-Newtonian fluid with the extention of a small amount of alumina nanoparticles[13].

II. METHOD & MATERIAL

1 Synthesis of nanofluids

The samples were prepared for characterization and experimentation by mixing nanofluids in double distilled water in a beaker and using ultra-Sonicator to properly mix the nanofluids. The samples were prepared in the following concentrations: 0.25 %, 0.5%, 0.75%, 1.0%, 1.5%, and 2.0% (each sample of 5–10 L in volume to be used in solar collector). To get a homogeneous solution, dispersed nanoparticles in the base fluid were kept under ultrasonic vibrator continuously for 8–10 h. An ultrasonic vibrator (Toshiba India) produces ultrasonic pulses of **100 W at 36 ± 3 kHz.**

A magnetic stirrer was used to break down agglomeration of particles and to properly disper. N'b[se nanoparticles in solution. The manufacturer supplied the nanofluid with added surfactant, Triton 100 X, in a very small quantity so that long term stability of the sample could be ensured without adversely affecting the basic characteristics of nanoparticles. During investigation, no sedimentation was observed even at a very low flow rate.

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2. Experimentation

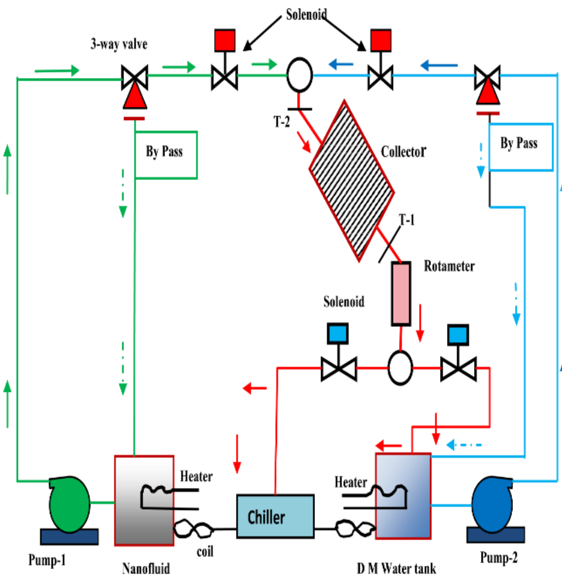

FIG:2Flat plate solar collector experiment setup[6]

FIG 1 Apparatus consist of solar modular (with adjustable inclination) having 8 halogen lights of 500 W capacity. Solar intensity can be varied by increasing power of halogen lights with knob. Maximum intensity observed in this system has been 1300 W/m^2 (average). There are two insulated steel tank having capacity 10 L with separate circuit for DM water and nanofluid. Chiller and heater devices are used to maintain set temperature of DM water and nanofluid circulate in circuit at one time. Pressure indicators gives loss in pressure in kPa between inlet and outlet.Rotameters measures discharge rate in lpm, range (0–5 lpm) with least count 0.1 lpm. K-type thermocouples are used to measure inlet (set) temperature and outlet temperature (T-2 and T-1) as shown in schematic.

To measure plate temperature there are 6 K-type thermocouples are attached with absorber plate surface. Solar radiation was measured by Solarimeter (TENMARS-TM207). It has capacity to measure intensity 0–2200 W/m^2. Modeler was attached with solar collector plate has maximum capacity 4000 W at 3000 K. Due to steady state radiation by modeler, thermal efficiency observed is higher than actual solar source where intensity of radiation also not steady compare to modeler.

III. RESULT & DISCUSSION

A. Effect of particle volume concentration on collector efficiency

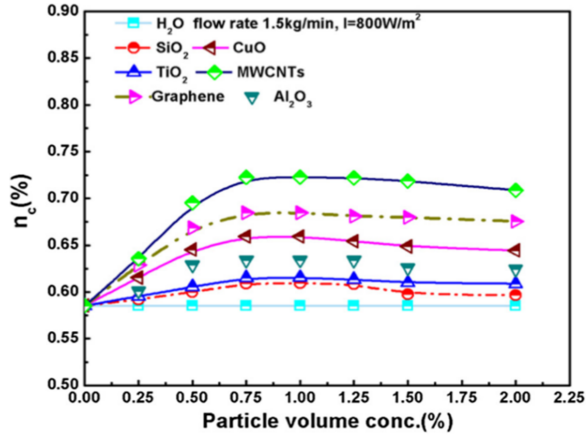

Fig.3. collector efficiency vs particle volume concentration[6]

- Fig. 3 presents a graph between efficiency and particle volume concentrations. Graphs, drawn for different nanofluids, shows that as particle volume concentration increases, efficiency increases as well for constant flow rate and given intensity of radiation.
- As it is clearly visible from graphs for different nanofluids, solar collector thermal efficiency is a function of particle volume concentration of nanofluids up to an optimum concentration.
- The maximum enhancement in efficiency reaches between 0.75 and 1% particle volume concentrations. It can be observed in MWCNTs, which is 23.47%, followed by 16.97%, 12.64%, 8.28%, 5.07% and4.08% by graphene/water, CuO/water, Al_2O_3/water, TiO_2/water and SiO_2/water nanofluids, respectively, at 0.75% particle volume concentration.
- A further increase in the concentration level has a nominal effect on efficiency as an increase in viscosity of fluid at higher concentration causes frictional dissipation and agglomeration of particles

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B. **Effect of mass flow rate on collector efficiency**

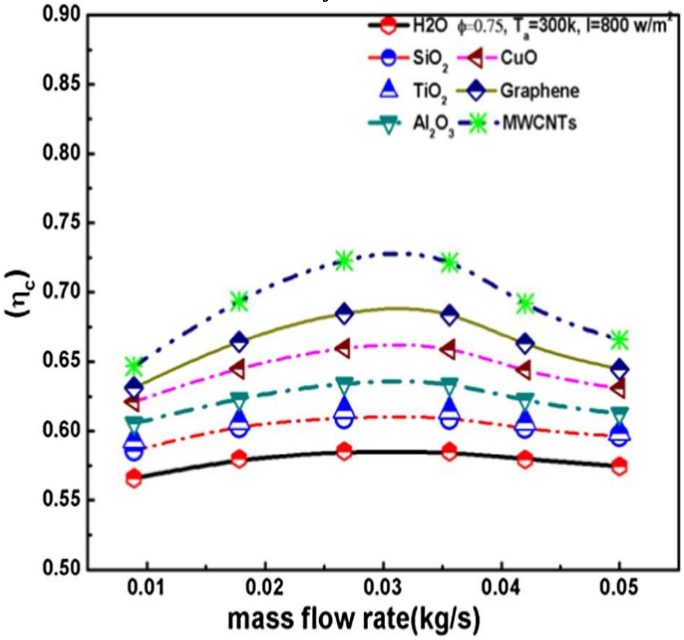

Fig.4. collector efficiency vs mass flow rate[6]

- Efficiency of solar collector is also a function of mass flow rate as shown in Fig.4. For each nanofluid, efficiency increases with the mass flow rate and the optimum rise in efficiency can be attained at 0.03 kg/s.
- For this flow rate, the maximum rise in efficiency can be observed in MWCNTs at a particle volume concentration of 0.75%, which is 23.5%.
- A decrease in efficiency can be observed at a higher flow rate due to a decrease in temperature difference between the outlet and the inlet of fluid.
- Also, at a higher flow rate, pressure drop increases which undermines thermal efficiency

C. Effect of intensity of radiation on collector efficiency

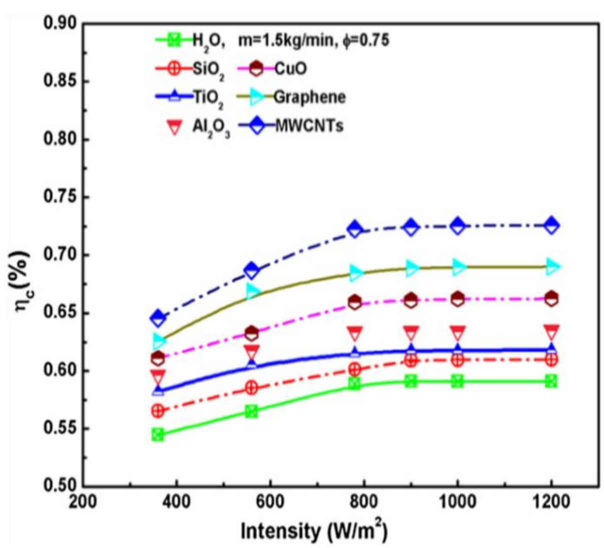

Fig.5. collector efficiency vs intensity[6]

- The effect of intensity variation on collector efficiency is shown in Fig. 5 with different nanofluids at constant mass flow rate and particle volume concentration.
- All nanofluids exhibit proportional rise in efficiency with increasing radiation intensity up to the optimum level.
- Beyond that point, efficiency gets saturated and remains constant due to proportionate increase in various losses incurred at higher temperature difference between the absorbing plate and the surrounding.
- For constant flow rate at 1.5 kg/min and particle volume concentration, the maximum gain in efficiency can be observed in MWCNTs/water, which is 24.5%, followed by graphene/water, copper oxide/water, aluminum oxide/water, titanium oxide/water and silicon oxide/ water as compared to water as base fluid.

IV. CONCLUSION

- The maximum enhancement in efficiency reaches between 0.75 and 1% particle volume concentrations. It can be observed in MWCNTs, which is 23.47%, followed by 16.97%, 12.64%, 8.28%, 5.07% and4.08% by graphene/water, CuO/water, Al_2O_3/water, TiO_2/water and SiO_2/water nanofluids, respectively, at 0.75% particle volume concentration.[6]
- Efficiency of solar collector is also a function of mass flow rate. For each nanofluid, efficiency increases with the mass flow rate and the optimum rise in efficiency can be attained at 0.03 kg/s.For this flow rate, the maximum rise in efficiency can be observed in MWCNTs at a particle volume concentration of 0.75%, which is 23.5%.
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