Comparative Study Of Water And Nano-fluid Based Parabolic Trough Collector

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ABSTRACT

Enhancement of heat transfer in solar collector using nano-fluid increases the overall performance of the system. The literature survey reveals that use of nanofluid enhance the performance of solar collector. Nano-fluid based solar collector are commonly used in areas such as heating and cooling for domestic purpose, thermal power plants, solar cooker, automobiles, etc.

The aim of the project is to analyze the performance of nanofluid based solar collector . The purpose of this project is to determine the effect nanoparticles have on heat transfer rates along with the effect deposition has on heat transfer rates using aluminum oxide nanoparticles at different concentrations, different flow rates, and at different temperatures .

Keywords *— Heat transfer, Solar collectors, Nanofluid.*

I. Introduction

A nanofluid is a mixture of water and suspended metallic nanoparticles. Since the thermal conductivity of metallic solids are typically orders of magnitude higher than that of fluids it is expected that a solid/fluid mixture will have higher effective thermal conductivity compared to the base fluid. Thus, the presence of the nanoparticles changes the transport properties of the base fluid thereby increasing the effective thermal conductivity and heat capacity, which ultimately enhance the heat transfer rate of nanofluids. Because of the small size of the nanoparticles (10-9 m), nanofluids incur little or no penalty in pressure drop and other flow characteristics when used in low concentrations. Nanofluids are extremely stable and exhibit no significant settling under static conditions, even after weeks or months. In their work (Lee & Choi) on the application of nanofluids reported significant cooling enhancement without clogging the micro-channels.

Advancements in material technology have provided the opportunity to produce material particles at the nano (10-9) scale. These particles have very different properties, like mechanical and electrical, than their full scale parent materials. Nanoparticles are particles' consisting of dimensions approximately 0.1-1000 nm in size. Some of the common oxide nanoparticles being used in heat transfer research are Zinc Oxide (ZnO), Copper Oxide (CuO), Aluminum Oxide (Al2O3), and Titanium Oxide (TiO2) while some of the metal nanoparticles are Gold (Au), Silver (Ag), and Copper (Cu).

Enhancement of heat transfer mechanism of nanofluids are attributed to chaotic movement of the ultra-fine particles and increase in thermal conductivity due to the suspension of nanoparticles, Nanofluids have the potential to revolutionize the way heating or cooling needs are met in the future. Nanofluids that are able to increase the efficiency of heat transfer will lead to lower operational and capital costs, which translates into cost savings, reduction of waste and positive environmental impact. However, nanotechnology is an emerging technology and research is needed to understand the mechanism of heat transfer in nanofluids and apply the benefits in thermal applications. Efforts are being made to recapture the nanoparticles suspended in the nanofluids before the nanofluid is to be recycled. If this process proves to be a success then nanoparticles can be continuously used and there would not be any concern of nanoparticles polluting the environment.

II. Literature Review

Based on comprehensive literature review, following points which has impact on our project.

Himanshu Tyagi et al., [1] they studied and theoretically investigate the feasibility by using a non-concentrating direct absorption solar collector and compare its performance with typical flat-plate collector. They used nanofluid as a mixture of water/ aluminium nanoparticles. The direct absorption solar collector was modelled numerically with twodimensional heat transfer analysis. They studied on various parameters, such as nanoparticles size and volume fraction, and collector geometry on the collector efficiency, and finally the performance of this collector was compared with that of a conventional flat-plate type collector. The collector efficiency was found to increase with particle volume fraction, glass cover transmissivity, and the collector height. However the direct absorption solar collector used nanofluids as the working fluid performs better as compare to flat plate collector. They observed that with the presence of nanoparticles increasing the absorption of incident radiation with more than nine times as compare to that of pure water. As from the results they obtained from study, under similar operating conditions, the efficiency of a direct absorption solar collector used nanofluid as a working fluid is found to be 10% higher than that of a flat-plate collector.

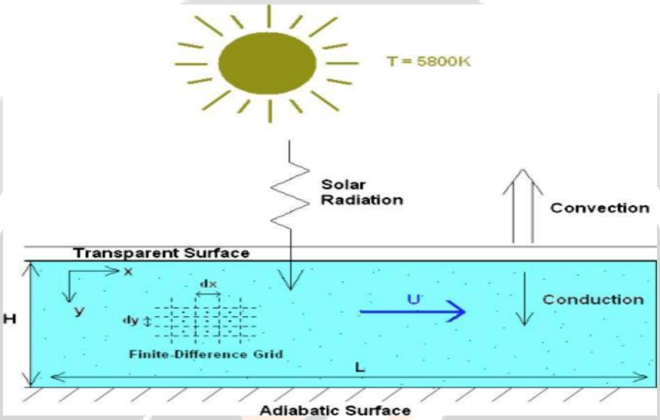
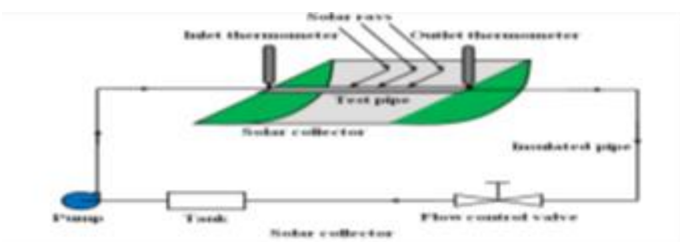


Fig. 1 Shows Nanofluid-based direct absorption solar Collector.

Patrick E. Phelan, et al., [2] they did experimental study on Nanofluid-Based Direct Absorption Solar Collector. They demonstrate efficiency improvement up to 5% in solar thermal collectors using nanofluids as an absorption mechanism. And they also compare experimental data with the numerical model of a solar collector with direct absorption nanofluids. They conclude that experimental and numerical results show an initial rapid increase in efficiency with volume fraction, followed by a levelling off in efficiency as volume fraction continues to increase. They conclude that using nanofluids as a direct absorption solar collector was demonstrated to offer unique advantages over conventional collectors are,

1. Heating within the fluid volume, limiting the need for a hot surface, which only transfers heat to a small area of fluid, and allowing the peak temperature to be located away from surfaces losing heat to the environment.
2. Variability in the size, shape, material, and volume fraction of the nanoparticles allow for tuning to maximize spectral absorption of solar energy throughout the fluid volume.
3. It enhance the thermal conductivity can lead to efficiency improvement, and more effective fluid heat transfer.
4. Greater enhancements in surface area due to the extremely small particle size, which makes nanofluid-based solar systems attractive for thermo chemical and photo catalytic processes.

III .Experimental Setup and Design of Experimentation



- Different component with specification

Sr no.	Component	Size	Description
1	Nano-powder	40nm	Aluminium oxide
2	Copper rod	Diameter 20mm & length 1300mm	Hollow shaft
3	Centrifugal Pump		35watt
4	Reservoir		3 Litre
5	Digital temperature indicator		Thermo-couple
6	Parabolic trough collector	Parabolic shape having length 1250mm, diameter 880mm & height 300mm	24 gauge steel sheet
7	Heat exchanger	Cylindrical	PVC

IV. Methodology

After reviewing the different research paper on parabolic trough collector, the topic was conformed and direction of project is decided. The experiment was performed on three different mass flow rates and three different concentrations, the reading was taken continue till nine days from 10:30 AM to 2:30 PM. First three days at 0.05% concentration and mass flow rate m_1, m_2, m_3 . Similarly for next six days at the duration of three days each we changes concentration 0.1%, 0.14% and mass flow rate.

1. Experimentation on copper pipe fitted inside glass tube with 0.05% volume concentration alumina/water nanofluid with 80Lit/Hr, 90Lit/Hr, 100Lit/Hr.
2. Experimentation on copper tube fitted inside glass tube with 0.1% volume concentration alumina/water nanofluid with 80Lit/Hr, 90Lit/Hr, 100Lit/Hr.
3. Experimentation on copper pipe fitted inside glass tube with 0.14% volume concentration alumina/water nanofluid with 80Lit/Hr, 90Lit/Hr, 100Lit/Hr.

V. Sample Calculations

To study the performance of nanofluid using parabolic solar collector, following formulae are used (Sukhatme S.P., 1984):

1) Heat supplied by solar

$$Q = \mathrm{m_{nf}} \times \mathrm{m_{cp}} (T_o - T_i)\ W$$

Calculation of mass of nanopowder

Total volume

$\mathrm{V} = 2.74969 \times 10^{-3}\ m^3$

1) For mass calculation Al2O3 for the maximum of 0.05% by volume

0.05% volume of 2.74969× 10^{-3} m^3 is 1.35135× 10^{-6} m^3

$$\rho nf = \frac{m1}{V}$$

$$3700 = \frac{m1}{1.35135\times10^{-6}}$$

Mass of nanoparticle (Al2O3) m_1 = 5gm

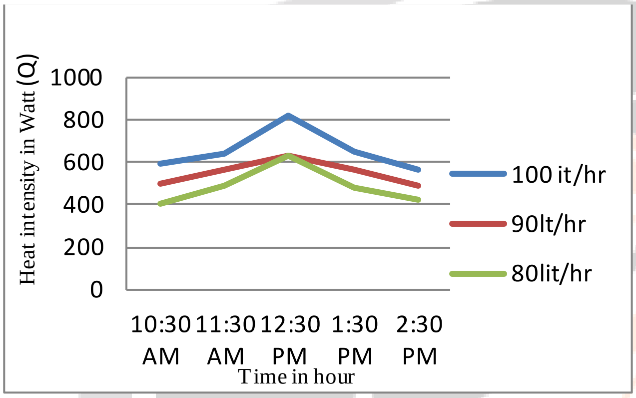
2) Similarly for 0.1% and 0.14% mass is calculated below

$$m_2 = 10\ gm$$

$$m_3 = 15gm$$

Where, $m_{1,}$ m_2 , m_2 =mass at different volume fraction

VI. Result and Conclusion



From this review, various ways of enhancing the heat transfer rate by using nano-fluids. Heat transfer rate varied according to the different concentration and different mass flow rates, as from various reviews the use of nano-fluid in solar collector indicates that, nano-fluid gives the best result for enhancing the heat transfer of solar collector as compare to the water based solar collector. It has been conclude that using nano-fluid in solar collector the heat intensity increases with the increase in mass flow rate and concentration of nanopowder.

VII. Future Scope

Based on the points discussed in conclusion, it has been observed that, there are still many areas left in the experimentation to enhance the performance of parabolic solar collector:

1) Manual tracking mechanism has been employed in the present work. Automatic tracking mechanism could be used to enhance the performance of the solar collector, so that maximum solar radiation can be absorbed.

2) In the present work, reflector consists of steel sheet of 25 gauge. Instead, a proper reflector can be used to reflect the maximum amount of solar radiations onto the receiver.

3) The support structure is fabricated and bolted on the floor to withstand the effect of wind, load etc. Other suitable materials can also be used in place of it.

4) The absorber tube is made up of copper. Stainless steel, Pyrex glass, quartz etc. can also be used.

5) The diameter and material of the cover tube can be varied to prevent the heat losses.

VIII. References

[1] H. Tyagi, P. Phelan, R. Prasher, “Predicted efficiency of a Low temperature nanofluid – based direct absorption solar collector”, J. Solar Energy Eng. Vol. 131, pp. 041004-1-7, Nov.2009.

[2] Todd P. Otanicar, Patrick E. Phelan, Ravi S. Prasher, Gary Rosengarten, and Robert A. Taylor, “Nanofluid-based direct absorption solar collector”. Journal of renewable and

sustainable energy **2**, 033102 _2010.

[3] Tooraj Yousefia, Farzad Veysia, Ehsan Shojaeizadeha, Sirus Zinadinib, "An experimental investigation on the effect of Al2O3eH2O nanofluid on the efficiency of flat-plate solar collectors". Renewable Energy 39 (2012) 293-298.

[4] Dnyaneshwar R.Waghole, R.M.Warkhedkar, V.S. kulkarni, R.K. Shrivastva, "Experimental Investigations on Heat Transfer and Friction Factor of Silver Nanofliud in Absorber/Receiverof Parabolic Trough Collector with Twisted Tape Inserts".
Energy Procedia 45 (2014) 558 – 567.

[5] kumar sunil, lal kundan, sharma sumeet, " Performance evaluation of a nanofluid based parabolic solar collector – an experimental study". Proceedings of Twelveth IRF International Conference, 31st August 2014, Chennai, India, ISBN: 978-93-84209-48-3.

[6] S. E. Ghasemi1, GH. R. Mehdizadeh Ahangar, " Numerical analysis of performance of solar parabolic trough collector with Cu-Water nanofluid". International journal of Nano Dimens.5(3): 233-240, Summer 2014 ISSN: 2008-8868.