Experimental Investigation on Performance of silver Nanofliud in Absorber/Receiver of Parabolic trough collector

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This experimental investigation presents synthesis and characterizations of silver Nanoparticle. This study also deals with improvement in performance of absorber/Receiver using silver nanoparticle dispersed in DI water (De-Ionized water).The silver nanoparticle suspended in conventional fluid have superior heat transfer capabilities .The absorber of parabolic trough collector is tested for heat input ranging from 50 W/²-600 W/m² in four steps which is suitable for removing heat from solar system, process industries, power plants, automobile systems marine systems etc. The effect of various operational limits and test parameters such as heat input, volume fraction, fluid temperature, heat transfer coefficient are experimentally investigated. The silver nanoparticle is tested for volume concentration in the range of $0 \leq \Phi \leq 0.1$ %, $500 \leq Re \leq 6000$, *experimentally with average silver nanapartice diameter 10nm-400 nm. The Characterizations of silver nanoparticle is carried out using TEM, UV and SEM methodology for required sample of silver nanoparticle. The experimental results are evaluated in terms of performance matrices by direct measurements of fluid temperature and surface temperature in the absorber. A substantial reduction in thermal resistance of 23.152% observed for 0.00011% concentration of silver nanoparticle. The Nussult number for absorber of parabolic trough collector with silver nanofliud varied from 1.25 to 2.10 times in comparison that of water.*

1. Introduction

A technique to enhance liquid thermal conductivity is the dispersion of highly conductive solid nanoparticle within the base fluid .This new generation of conductive fluid with nanoparticle is referred to as nanofliud. Taehyau Cho et.al [1] investigated thermal conductivity of fluid suspended with silver nanoparticle. The observations conclude an important increase in thermal conductivity by 10%,16% and 18% for concentration of 1000,5000and 10000 ppm . Paison Naphen et.al [2] experimentally investigated titanium nanofliud on heat pipe thermal efficiency .The heat pipe with de- ionized water ,alcohol and nanofliud (Alcohol and nanoparticle) are tested .The titanium nanoparticle with diameter of 21 nm are used in the present study.The effect of % charge of amount of working fluid ,heat pipe tilt angle and % nanoparticle volume concentration on thermal efficiency of heat pipe are concluded for the heat pipe with 0.1% nanoparticle volume concentration. The thermal efficiency is 10.60% higher than that with base fluid. Tsaisa et.al [3] investigated the influence of particle size on heat pipe thermal performance .The study is based on structural characteristics of Gold nanoparticle of various sizes dispersed in aqueous solution on heat pipe thermal resistance .The thermal resistance of heat pipe ranges from 0.17 to 0.215 ˚C/W with different nanoparticle solution. Furthermore the thermal resistance of heat pipe with nanoparticle solution is lower than that with DI water. King et.al [4] used dilute dispersion of silver nanoparticle in pure water as working fluid in a circular heat pipe. The diameter of nanoparticle used is 10 and 35 nm respectively. The results showed that the nanofliud as working fluid in heat pipe can transport heat up to 70 W and is higher than pure water by about 20W.Park et.al [5] and Shang Wen Kang et.al [6] also observed in another study that silver nanofliud grooved heat pipe thermal performance was higher than that for a conventional grooved heat pipe water as working fluid. Zhan Hua Lin ,Yan Li et.al [7] studied compositive effect of nanoparticle parameter on thermal performance of cylindrical micro grooved heat pipe using nanofliud .L Godson et.al [8] studied experimental investigation of thermal conductivity and viscosity of silver deionized water nanofliud. Lazarus Godson Asirvatham et.al [9] studied heat transfer performance of screen mesh wick heat pipe using silver water nanofliud. Pak et.al [10] studied hydrodynamic and heat transfer of dispersed fluid with sub micron metallic oxide particle. K.S.Reddy and K.Ravikumar [11] studied numerical simulation of energy efficient receiver for parabolic trough collector.Balbir Singh [12] had studied simulation of convective heat transfer coefficient in receiver tube of parabolic trough collector. K.S.Reddy and K.Ravikumar [13] studied thermal analysis of Solar Parabolic trough with Porous disc receiver. E.Belgen [14] had studied heat transfer in inclined rectangular receiver for concentrated solar radiations. L.Syam Sundar and K.V.Sharma [15] were studied turbulent heat transfer and friction factor of Al2o3 Nanofliud in circular tube. It is obvious from above literature review that case of forced convective heat transfer in absorber utilizing silver nanofliud under uniform heat flux boundary condition seems not to have been investigated in past and this has motivated the present study.

2. Experimental Approach

The experimental arrangement consist of the testing receiver/absorber, Heat transfer fluid tank, pump, heater, temperature control system, data acquisition systems, valves, pipes etc. The heat transfer fluids (water and Nanofliud) are pumped through the flow meter into receiver /absorber and continued to be heated to the required experimental temperature. The receiver is heated by electrical heater (Solar radiation). The heat flux on testing receiver/absorber can be changed to the required value by changing the output of electrical heater. The Experimental setup is as shown in fig 1.

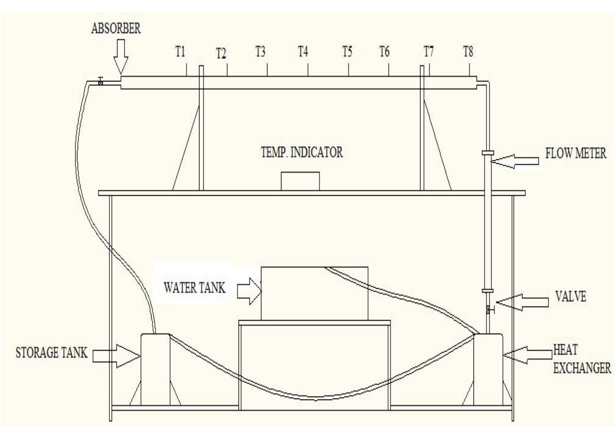

Fig. 1. Experimental Arrangement

3. Synthesis and Characterizations of Nanofliud

Nanoparticle used in present study is silver. Several studies, including the earliest investigations of nanofluids, used a two-step method in which nanoparticles are first produced as a dry powder and then dispersed into a fluid in a second processing step. In contrast, the one-step method entails the synthesis of nanoparticles directly in the heat transfer fluid. A two step method is used to prepare silver –water Nanofluid. Nanoparticle is mixed with De-ionized water without addition of any surfactant [9]. In present work, one step method is used and SEM technique is used for characterizations.

4. Results and Discussion

The experiments are conducted for various heat loads 50W-600W (500 W/m^2-6000W/m^2) with absorber in horizontal position .The surface and fluid temperature using thermocouple connected to data logger system. The experimental results are compared between base fluid and nanofliud for all concentration and the enhancement in heat transfer performance with respect to concentration, heat load, and thermo physical properties etc are discussed in following subsection. The effect of using twisted tape inserts in absorber /receiver on heat transfer characteristics is shown in fig 2, fig 3.It shows that the Nussult Number obtained from absorber with inserts is higher than plain absorber. It is depicted that the effect of tape inserts increased at high Reynolds Number due to the intensive mixing of fluid which increased the heat transfer rate and high flow velocity. Thus the increase in Nussult number is low at smaller Reynolds Number while it became greater at the higher Reynolds Number. The heat transfer rate is also changed with the helix angle of the tape inserts. It is higher with minimum helix angle. The experimental data for comparison of Nussult Number and friction factor are not available in literature for nanofliud with twisted tape insert. Hence, the present data for flow of water and Nanofliud in absorber and with twisted tape inserts is subjected to regression and the correlation function is obtained and shown in fig 4. We investigated the influence of thermic fluid properties, receiver geometries, and Heat flux on overall heat collection. We can see that by Numerical simulation, the velocity reaches a constant value beyond a certain distance from the inlet (fig 5.) This is the fully-developed flow region. We can see that the fully developed region is reached at x =0.4 m and skin coefficient in this region is 3.25 (Fig 6)

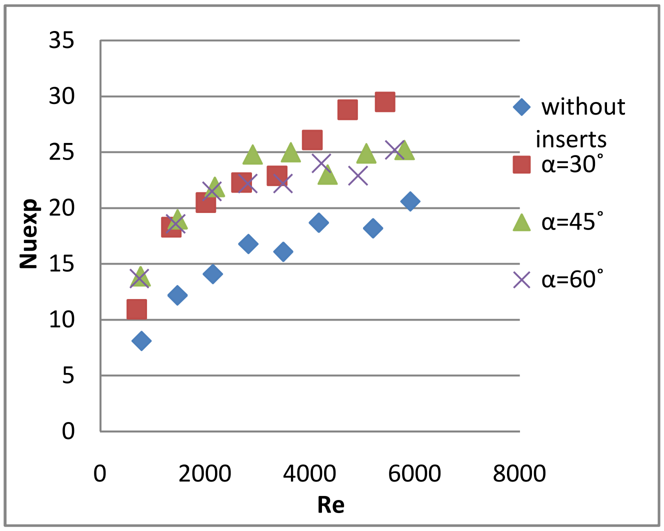

Fig 2 Influence of Angle of twist on Nusselt Number

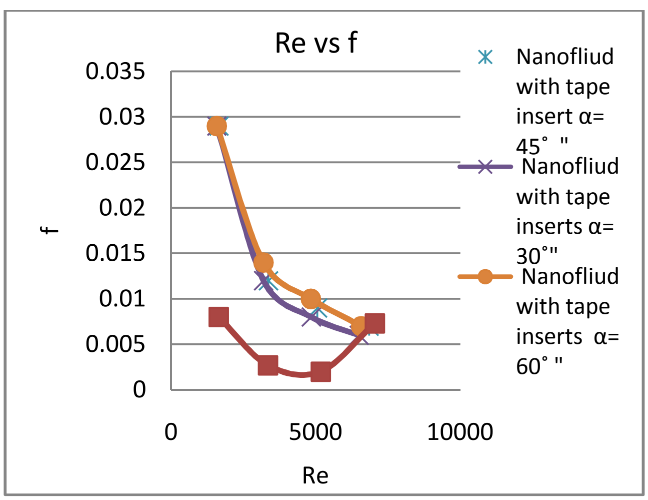

Fig 3 Influence of Angle of twist on Friction Factor

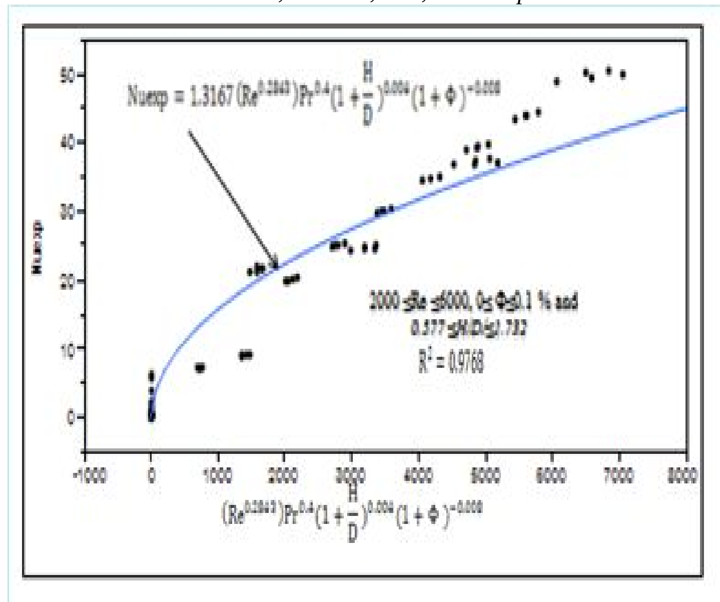

Fig 4 Generalized heat transfer correlation for Absorber

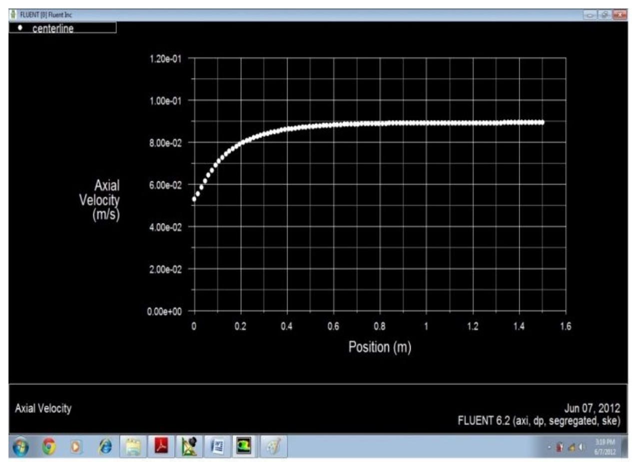

Fig 5 Effect of Axial velocity

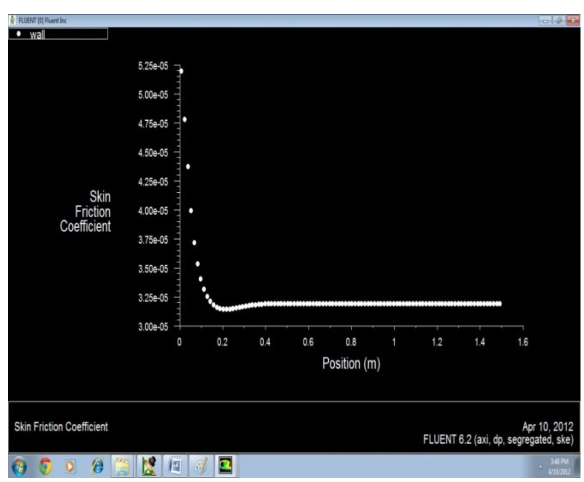

Fig 6 Effect of skin friction coefficient

5. Conclusion

It is observed that convective heat transfer coefficient increase with increase in concentration of silver nanoparticle. An experimental and Numerical study is conducted to investigate heat transfer enhancement in an absorber by means of twisted tape inserts. The study reveals that tape inserts caused an increase of heat transfer at the cost of increase of pumping power. From the experimental and Numerical results the following could be concluded:

i) The Nussult Number for absorber with tape inserts varied from 1.25 to 2.10 times in comparison that of plain absorber.
ii) There is no significant increase in pressure drop or friction factor for silver Nanofliud in comparison to water at the same twist ratio.
iii) *A substantial reduction in thermal resistance of 23.152% observed for 0.00011% concentration of silver nanoparticle*

The proposed generalized correlation function for turbulent flow for water and Silver Nanofliud for flow in plain absorber and with twisted tape inserts are as follows :

$$\mathrm{Nuexp} = 1.3167(\mathrm{Re}^{0.2843})\mathrm{Pr}^{0.4}\left(1+\frac{\mathrm{H}}{\mathrm{D}}\right)^{0.004} (1+\Phi)^{-0.008} \quad (1)$$

Valid For the range 2000 ≤Re ≤6000, 0≤ Φ≤0.1 % and *0.577 ≤H/D/≤1.732*

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Nomenclature

D	Diameter of absorber
H	Pitch of tape inserts
Nu	Nusselts Number
Pr	Prandle Number
Re	Reynolds Number
Greek symbols	
α	helix angle
Ø	volume fraction
Subscripts	
exp	experimental

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