EXPERIMENTAL STUDY ON HEAT TRANSFER AUGMENTATION IN HELICALLY COILED TUBE SOLAR COLLECTOR WITH MWCNT / WATER NANOFLUID

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ABSTRACT
In this study the heat transfer of the direct cylindrical glass solar collector are investigated experimentally. The MWCNT /water nanofluids at 0.3% particle volume concentration and 0.25% weight percentage added in to SDS as surfactant was prepared by two step methods. It was found that the cylindrical solar collector efficiency of 10 -29 % higher than the water. This may be due to random motion of the flow particles and higher thermal conductivity of nanofluid. It is concluded that MWCNT /water based nanofluid can be applied as heat absorption in tube helical coiled solar collector at 0.3% particle volume concentration without significant of pressure drop.

Key word: Cylindrical solar collector, helical coiled tube, MWCNT/water, collector efficiency.

I. INTRODUCTION
Several experimental and theoretical studies have been carried out by various research team for augmentation heat transfer performance of solar collectors using new traditional fluids as a nanofluids. The revo-lution of nanotechnology conceived the concept of nanofluid. Argonne National Laboratory, Choi [1] was the first to employ suspended nanoparticles in base fluids. Assael et al., [2] observed a thermal conductivity enhancement in water stabilized by SDS. Result shows that increased thermal conductivity, the large aspect ratio. Ding et al., [3] measured the effective thermal conductivity increased with measuring temperature and volume concentration of MWCNT dispersed in water with Gum Arabic as a surfactant. Kumaresan et al., [4] investigated the thermo physical properties MWCNT water – ethylene glycol mixture based nanofluids with SDS as surfactant. The maximum enhancement of thermal conductivity 19.75% at 0.45 vol% MWCNT. Das et al., [5] measured the thermal conductivity of nanofluids containing Al2O3 nano particles and investi-gated the effect of base fluid on the thermal conducti-vity. Wen et al., [6] presented the convective heat trans- fer improved in the laminar flow region with Al2O3 nanoparticle with base fluid as a water. It is found that convective heat transfer coefficient enhanced with Reynolds number with increase nano particle volume concentration. Suresh etal., [7] proposed the convective heat transfer and friction factor characteristics of heli-cally and plain dimpled under turbulent flow condition by the Cuo water based nanofluids. The heat transfer rate increase with increase Nusselt number at high volume concentration. Wang et al., [8] investigated the heat transfer and pressure drop working fluids as water based CNT nanofluids in circular tube as horizontal position. The indicate enhancement of average convective heat transfer increase with increase the volume concentration of nanoparticles at constant Reynolds number. Mukesh kumar et al., [9] studied heat transfer and pressure drop in helically coiled tube heat transfer working fluid as Al2O3 nanofluids under a turbulent flow region. The increase heat transfer coefficients and pressure drop with increase the particle concentration. Yousefi et al., [10] observed the experimental efficiency of flat plate solar collector is higher than water at 0.2wt.% Al2O3/ water nanofluids. Otanicar et al., [11] investigate the various nanofluids like CNT, Ag and graphite in direct absorption solar collector. It is found that the performance of a micro scale solar collector increase the efficiency of the solar thermal collector while using nanofluids. Taylor et al., [12] investigated the graphite based nanpaticle in solar collector with high heat flux. It is found that increase performance of collector due to the increase the nanofluids concentration. Tyagi et al., [13] proposed the theo-retically different operation parameter in direct solar absorption collector with target fluid as a water and Ag nano-fluids. The increasing efficiency with increase adding nanoparticle and remarkable for high particle concentra-tion of nanofluids. Mahian et al., [14] presented the utilization of nanofluids in solar collector devices. To obtain nanofluids have stable with uniform suspension of nanoparticle in the base fluids. The pH value is control of nanofluids is an technique to identifying dispersion the aggregated nanoparticle in base fluids. It indicate the more agglomerates in nano particle to reduced the thermal conductivity of nanofluids. Chandrasekar et al., [15] review on the thermal regu-lation techniques for non integrated flat PV modules mounted on building have reviewed and discussed utilizing Nanofluids in solar energy devices. Lee et al., [16] proposed the Cuo/water nanofluids varied far from the repulsive force between the particle surface and base fluid surface to control the pH value of the nanofluids. The colloidal suspension nano fluid are good stability and high thermal transport properties.

II. METHODOLOGY AND MATERIALS
The MWCNT nanoparticles were purchased from Nanostructured & Amorphous Materials,Inc. Houston, TEXAS and USA. The purchased MWCNT nanoparticles were characterized by XRD fig 1. The average particle size was determine to range of 50 to 80 nm using XRD pattern of nanoparticles. In this investigation 0.3 % volume concentration of MWCNT water based nanofluid is prepared by using two method. Because two step method is better for oxide particles and this method gives higher stability and less agglomera-tion. The MWCNT water based nanofluids is prepared at 0.3% volume concentration and characterized with TEM fig 2. The required amount of nanoparticles
was taken and dispersed in distilled water. Ultrasonic bath (Citizen, India) generating Ultrasonic pulses 110W at 40 ± 5kHz was switched on for 1 hour to get the uniform dispersion and stable suspension of nano-particles. Nanoparticles are stable and tiny agglomerated particles are spherical in shape. It is observe that there was no visible settlement of nanoparticles even after three months of static condition of nanofluid. The Sodium dodecylbenzene sulfonates (SDBS) as a surfactant was used to maintain the stability of nanoparticles in base fluid.

Fig. 1. XRD image of MWCNT nanoparticles

Fig. 2. TEM image of MWCNT 0.3 Vol % nanofluid.

A. Experimental procedure:
The schematic line diagram of the experimental setup are shown in Fig.3. The experimental setup has glass cylindrical loop side and helical coiled tube side loop (1 in Fig. 3). The glass cylindrical side handle to absorb the solar radiation. The helical coiled tube loop handle the working fluids as water and MWCNT/ water nanofluids as a target fluids. The cylindrical solar collector pipe to minimize reflectivity and avoidable reflection of solar heat energy by wall surface and the more solar energy of heat passing through and helical coiled tube absorption is high due to higher thermal conductivity of coiled tube material.

Table 1. Specification of Cylindrical glass collector

<table>
<thead>
<tr>
<th>Specification</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorption area</td>
<td>0.471</td>
<td>m²</td>
</tr>
<tr>
<td>Cylindrical glass</td>
<td>L = 600, D1 = 9.5, D2 = 10</td>
<td>mm</td>
</tr>
<tr>
<td>Copper coil</td>
<td>L = 555, D1 = 8, D2 = 10</td>
<td>mm</td>
</tr>
<tr>
<td>Thermal conductivity of glass</td>
<td>k = 1.3</td>
<td>W/mK</td>
</tr>
<tr>
<td>Thermal conductivity of copper coil</td>
<td>k = 389</td>
<td>W/mK</td>
</tr>
<tr>
<td>Transmission coefficient of the glass</td>
<td>τ = 0.75</td>
<td>-</td>
</tr>
<tr>
<td>Absorption coefficient of absorber</td>
<td>α = 0.77</td>
<td>-</td>
</tr>
</tbody>
</table>

Fig. 3. Schematic diagram of experimental setup (Glass cylindrical collector and Helically coiled test section)

This coil (2 in Fig.3) in helical pipe and inner tube diameter and outer tube helical coil are 8 mm and 10 mm respectively, operates as a receiver and the inlet, outlet pressure drop is noted by using pressure gauge. The specification of solar collector are given in Table 1. The measurement of inlet and outlet temperature of fluids were used two K type thermocouple of 0.1°C accuracy. Thermocouple are locate inlet and outlet of the helical coiled tube collector (3 in Fig.3). In this connection the convective heat transfer are take place in forced with electrical pump (4 in Fig.3). A ball valve is provide in flexible PVC hose to regulate the volume flow rate of working fluids. The mass flow rate of the tube side on 0.03kg/sec, fluid is measured by standard jar. Each of working fluids (water, and MWCNT nanofluids) is of a different thermal conductivity and specific heat, thereby the volume concentration of working fluid is changed. Reservoir (6 in Fig.3) which is used to store the fluid and capability of transferring through the copper tube using centrifugal pump which is about 0.5 HP.

Anemometer is also used to measure the wind flow while the experiment carried out initially and the value is about 30 m/s at maximum case. The vertical stand which lifts the cylindrical glass tube accompanied with pressure gauge (7 in Fig.3) and thermocouples. A
pyranometer is used to measure the solar radiation flux density (W/m²). The fluids can be transferred from reservoir to inlet and outlet through the copper tube by the use of 12 mm PVC flexible hose pipe.

III. RESULT AND DISCUSSION:

The time alone with X axis in hrs. With respect to Y axis temperature in °C is denoted and set of readings are plotted in the graph which is shown in the fig (2) from 10 am to 3 pm. The performance measure of water is analyzed from the gradual increase in temperature when it is used as coolant. The primary stage which stretches water as working fluid and later it can be replaced by nanofluids.

A. Comparison Of Performance Measure Water Vs Mwcnt

The batch of readings are noted and the graph was plotted which is shown in the fig (4). Here the comparison among both the water and MWCNT with regular intervals followed by coolants the heat transfer rate is taken and denoted in temperatures and MWCNT which possess high efficiency rate than the water. The color indication which differs the outlet values of water and nanofluid separately in equal and regular intervals.

IV. CONCLUSION

This study investigated the performance characteristics of a nano fluid based cylindrical solar collector with helical coiled copper tube. The experimental work is carried out using water and 0.3% particle volume concentration MWCNT/water based nanofluid were prepared and characteristics by using XRD and TEM. The nanofluids based glass cylindrical solar collector has the potential heat energy absorption and more efficient compare to flat plate solar collector. By using MWCNT as a working fluid temperature absorption rate is about 29.16 % higher than water and also the heat transfer rate comprises about 17.62 % increase than the water which can be used as a working fluid. The enhancement due to higher thermal conductivity of MWCNT/water nanofluids and better mixing of fluids. The helical coiled flow pattern was induced strong centrifugal force and random movement of nano particles which carry more solar heat energy. It is found that not required to direct absorption of solar radiation because of glass collector shape in cylindrical. Therefore, the conventional heat transfer
fluids can be replaced with nanofluids in glass cylindrical helical coiled tube collector for increase more heat transfer without significant of pressure drop.

REFERENCES: