Effect on the efficiency of Solar Collectors using Flowing Fluids as Absorber Element

Rahul Shukla[1], Ambuj Kumar[2], and Shashank Kumar[3]

[1]*(Research Scholar, Department of Mechanical Engineering, K.N.I.T Sultanpur, India)*

[2,3]*(Asst. Prof., Department of Mechanical Engineering, K.N.I.T Sultanpur, India)*

Abstract: *In this study, nanofluids at different volume ratio and different size were made by two-stage method. their thermal conductivities and the effect of due to nanofluids on the efficiency of various solar collectors has been observed experimentally. Meanwhile, the temperature of water, heat absorbed by the solar water collector and the frictional resistance coefficient of working fluid were also observed.*

The mass flow rate of medium has been taken 80ml/h. The results of experiment show that the thermal conductivities enhanced observably. Solar collector efficiency has been increased by 13.53%after using CueH_2O nanofluids (15 nm, 0.1 wt%) at the place of absorbing medium. The efficiency of solar collector using CueH_2O nanofluids (15 nm, 0.2 wt%) is lower than that of CueH_2O nanofluids (15 nm, 0.1 wt%).One more observation has been done that on nanoparticle size increment reduction in the efficiency of solar collector . The maximum temperature and maximum heat gain of water in the nanofluid (15nm, 0.1 wt%) tank can be increased up to 14.24% and 28.52% as compare with water tank, respectively. The rate of increase of the frictional resistance coefficient is less than 2% in the whole working temperature area. As per the results, it can be shown that the CueH_2O nanofluids is suitable for enhancing the efficiency of flat-plate solar collector.

Keywords: *nanofluids; solar collector; solar absorber; exergy; optimization.*

I. INTRODUCTION

Solar Energy

Universe is running by an ultimate energy source which is solar energy emitted by sun. It is source of all energy whether being conventional or non-conventional, renewable or non-renewable, wind or tidal energy any type of energy . they all taken energy by sun weather directly or indirectly.Very instresting thing about solar energy the sun emit such amount of energy in onec day which whole world recquired in 100 days but due to lack of storage system a huge amount has wasted. To utilize the solar energy the researcher are doing a lot researches on it.

In this work we are going to increase the efficiency of the solar absorber by using some technics and a lot researches has been done to find out the best condition at which maximum amount of solar energy can be utilize.

For this we have prepared a setup

Solar Energy Collector

Basically two types of solar collector is in use:

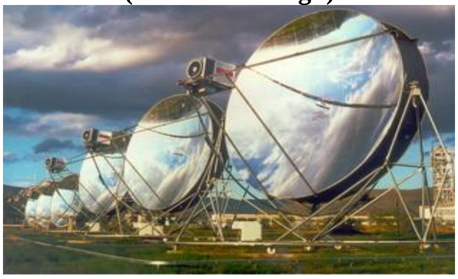
i) Non-Concentrating or flat plate type solar collector
ii) Concentrating type solar collector

1-Non-Concentrating or flat plate type solar collector

Figure. Soler Power Project Haridwar-1 Uttarakhand

2-Concentrating Solar Collector:

(Parabolic trough)



(Dish type collector)

Most prominently used of the solar collectors are flat plate collectors**.** Flat plate collectors were brought to existence by HOTTEL and WHILLIER in the 1950s. Flat plate collectors are encapsulated in a box with the glazing (glass or plastic cover) and a black coloured absorber plate. These collectors heat up liquid or air at a temperature of less than 80˚C. Flat plate collectors are additionally arranged depending upon the fluid used (e.g. Liquid heating collector or solar air hater). Important parts of the collector are given in the Figure -

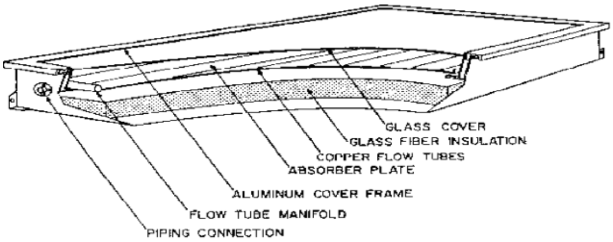
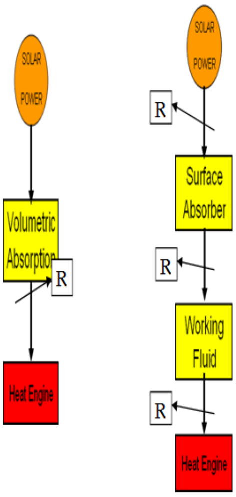


Figure. Components of a Flat Plate Collector.

There arises a requirement to utilize energy proficient heat exchange liquids the mere purpose of obtaining high efficiencies. One such method efficiency augmentation is the use of nanofluids in solar collectors. These fluids can be made use of in the solar collectors as nanofluids are the composition of nanosized particles which are dispersed in some base fluid or combination of base fluids.

$$Ra_1 + Ra_2 < Rb_1 + Rb_2 + Rb_3$$

$$\text{Where, } Rb_2 = Rcv + Rcd$$



(a) (b)

Figure (a. DASC, b. Conventional flat plate collector)

II. METHODOLOGY

The thermal performance of the flat-plate collectors were evaluated by the ASHRAE Standard 86-93. The collecting efficiency, water temperature and heat gain were compared in the same solar irradiation. The tests have performed from 9:00 to 16:00. The volume flow rate of working fluids is 1L/h. The heat gain of fluids can be calculated using Eq. The heat gain of fluids can also be expressed in terms of the energy absorbed by the absorber and the energy lost from the absorber.

Assumptions

In order to analyze certain assumption are made. They are:

1. The base wall is thought to be adiabatic.
2. The fluid is encased by a glass cover at the top.
3. The uppermost surface is thought to be presented to the encompassing atmosphere, so the heat losses are due to convection.
4. Atmospheric absorption is neglected.

III. RESULT & DISCUSSION

Here a thorough elucidation of the result and their analysis, which were obtained after perming the experiment are given and shown. Here calculation DASC is followed by the variation it shows in efficiency and also the effect of nanofluid on the collector's performance.

Solar Collector Performance Calculations

The experimental efficiency of the collector is:

General Expressions

Heat Absorbed by Solar Collector

$Q_a = m\,C\,(T_2 - T_1) \times 1000$ W…

Total Mean Solar Radiation falling on Solar Collector

$Q_i = G_T A C_r$

$\eta = m\,C\,(T_2 - T_1) / G_T A C_r$

$m = \rho \times v$…

Equations nanofluids

$\eta = m\,C_{eff}(T_2 - T_1) / G_T A C_r$

$m = \rho_{eff} \times v$….

$\rho_{eff} = (1 - \phi)\,\rho_f + \phi\rho_p$

$\phi = V_p / (V_p + V_f)$ …

$\mathbf{C_{eff} = \{(1 - \phi)\,\rho_f\,c_f + \phi\rho_p c_p\} / \rho_{eff}}$

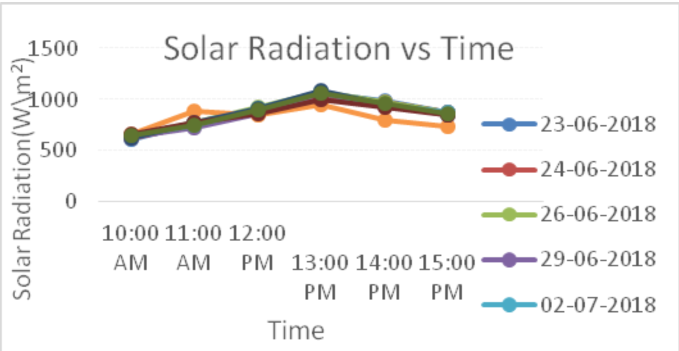
As per ASHRAE standard, this experiment inlet fluid temperature of the DASC is assumed as 29˚C. Correction factor 'C_r' the collector is taken as 0.92. The correction factor is introduced to compensate the heat lost from the collector via. convection, dust and wind.

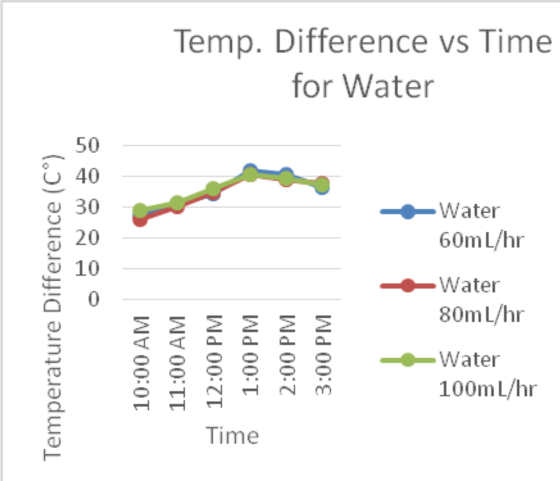
As the augmentation of mass flow rate takes place in the DASC there is a minute change in temperature difference but a drastic increment in efficiency. The most convincing reason would be that percentage change in temperature difference is very less in comparison to efficiency. It is easily evident that there is augmentation of temperature difference till 1:00 PM and then it decreases, whereas collector efficiency, its lowest value is at 1:00 PM. The reason being the rate of heat absorption capacity is lesser than the rate in increment in solar irradiation falling on earth.

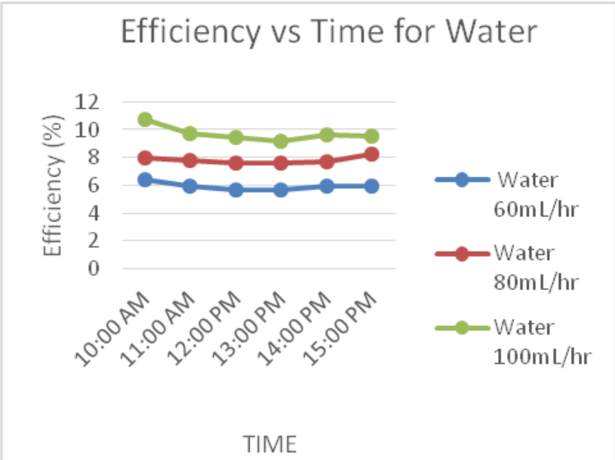
At CuO (φ = 0.05%) Nanofluid

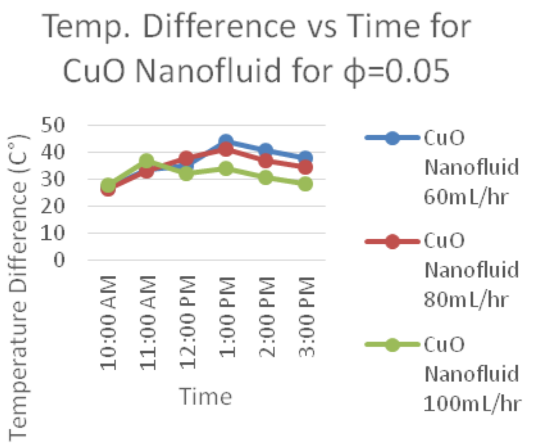
Density of Base fluid (water) $\rho f = 1000$ kg/m^3

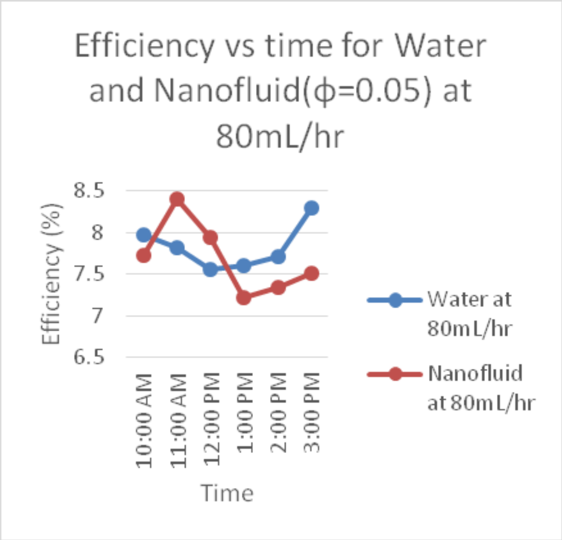
Variation of temperature difference and collector efficiency CuO nanofluid of volume fraction 0.05% throughout the day graph that the value of efficiency of nanofluid is greater as compared to that of water because of better thermophysical properties possessed by it, although now and again the efficiency of water was found to be higher.

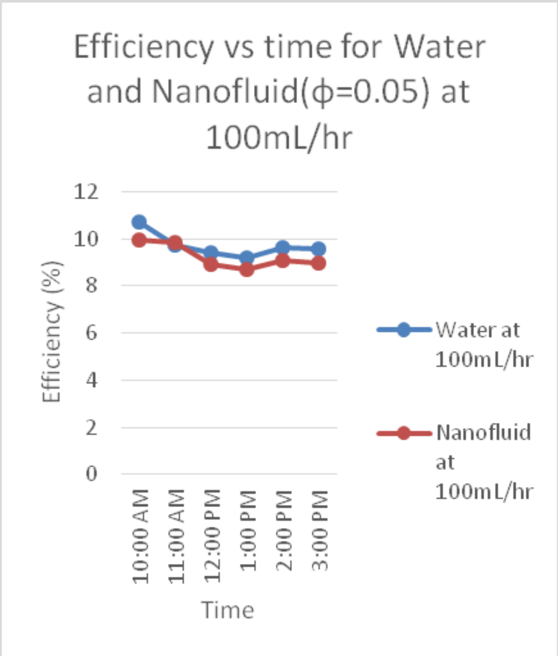


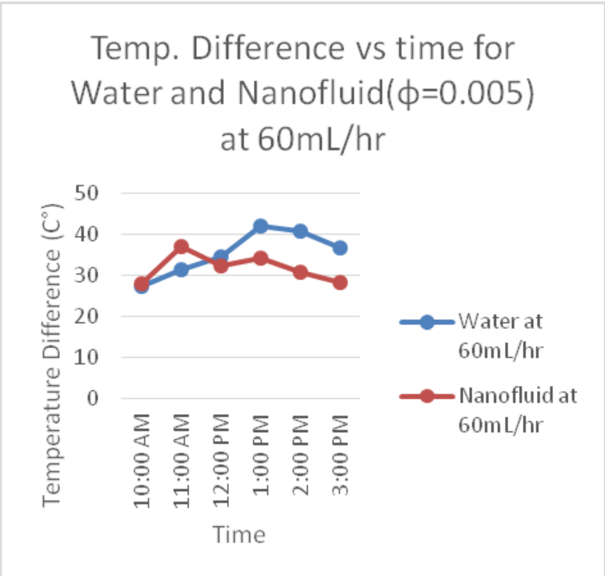

Temp. Difference vs Time for Water
Temperature Difference (C˚)
50
40
30
20
10
0
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
Water 60mL/hr
Water 80mL/hr
Water 100mL/hr

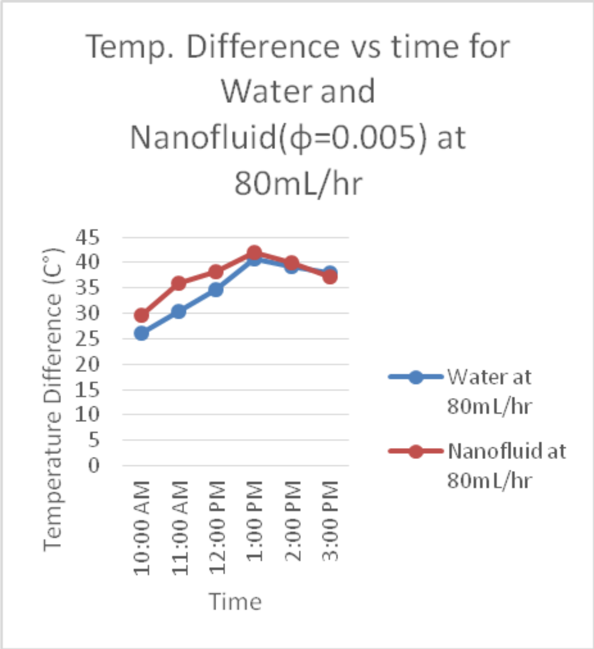

Efficiency vs Time for Water
Efficiency (%)
12
10
8
6
4
2
0
10:00 AM
11:00 AM
12:00 PM
13:00 PM
14:00 PM
15:00 PM
TIME
Water 60mL/hr
Water 80mL/hr
Water 100mL/hr

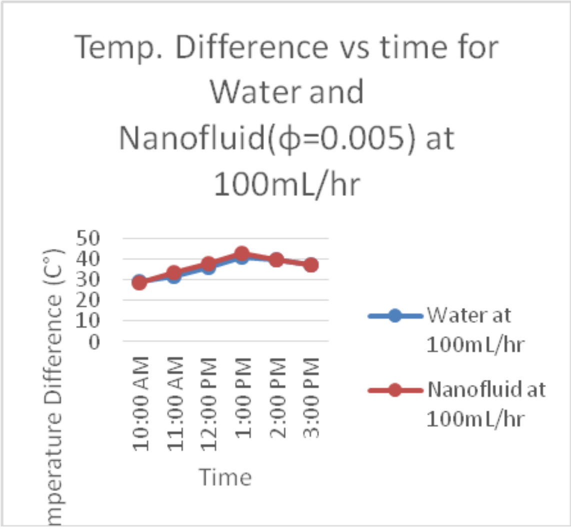

Temp. Difference vs Time for CuO Nanofluid for ϕ=0.05
Temperature Difference (C˚)
50
40
30
20
10
0
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
CuO Nanofluid 60mL/hr
CuO Nanofluid 80mL/hr
CuO Nanofluid 100mL/hr

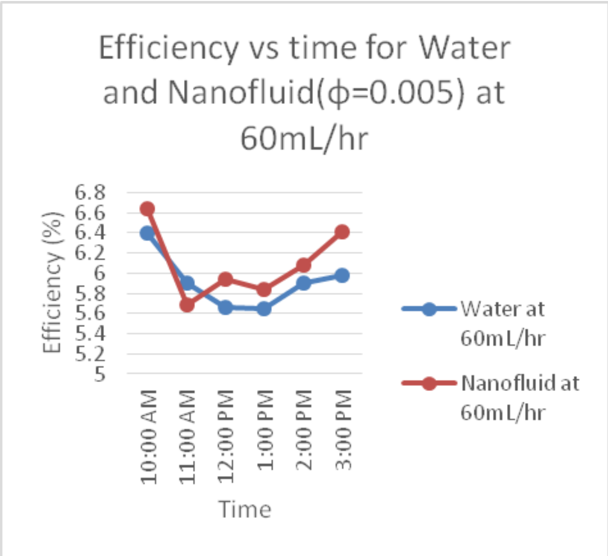

Efficiency vs time for Water and Nanofluid(ϕ=0.05) at 80mL/hr
Efficiency (%)
8.5
8
7.5
7
6.5
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
Water at 80mL/hr
Nanofluid at 80mL/hr

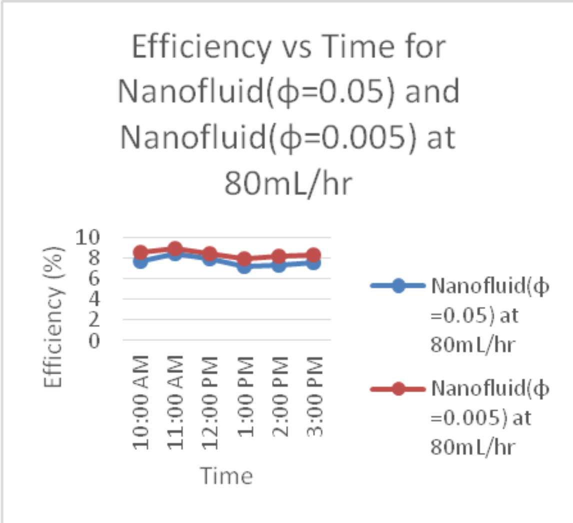

Efficiency vs time for Water and Nanofluid(ϕ=0.05) at 100mL/hr
Efficiency (%)
12
10
8
6
4
2
0
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
Water at 100mL/hr
Nanofluid at 100mL/hr

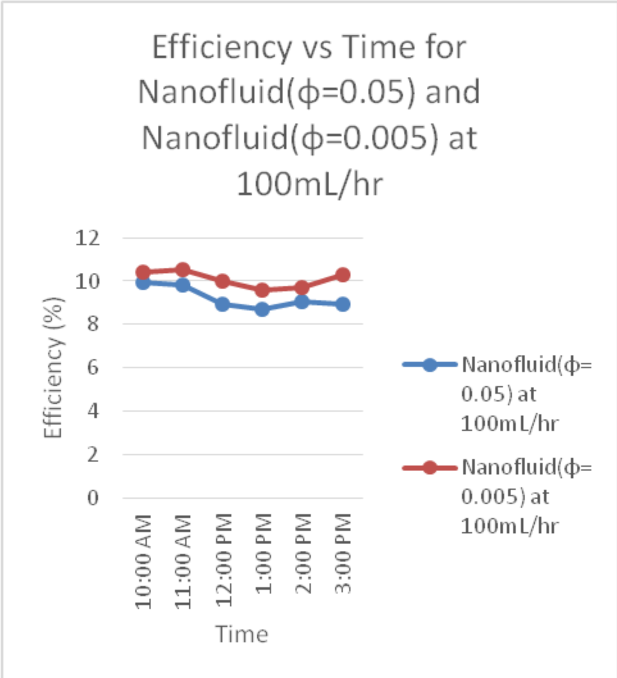

Temp. Difference vs time for Water and Nanofluid(ϕ=0.005) at 60mL/hr
Temperature Difference (C°)
50
40
30
20
10
0
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
Water at 60mL/hr
Nanofluid at 60mL/hr


Temp. Difference vs time for Water and Nanofluid(ϕ=0.005) at 80mL/hr
Temperature Difference (C°)
45
40
35
30
25
20
15
10
5
0
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
Water at 80mL/hr
Nanofluid at 80mL/hr


Temp. Difference vs time for Water and Nanofluid(ϕ=0.005) at 100mL/hr
mperature Difference (C°)
50
40
30
20
10
0
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
Water at 100mL/hr
Nanofluid at 100mL/hr


Efficiency vs time for Water and Nanofluid(ϕ=0.005) at 60mL/hr
Efficiency (%)
6.8
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
Time
Water at 60mL/hr
Nanofluid at 60mL/hr





Performance of Solar Energy collector using CuO nanofluid as volume fraction (ϕ = 0.005%):

As per observation the efficiency and variation in temperature difference having same profile when using CuO as nanofluid of volume fraction 0.005% whole day. At the time when solar irradiation were at highest value, at that time efficiency has the least value & temperature difference has the maximum value collector efficiency is more when using CuO as nanofluid (φ = 0.005%) than water as well as temperature difference is more CuO nanofluids as compared to water. The variation in temperature difference though is in the range of 2˚C - 3˚C as the thermal conductivity of CuO nanofluid is higher as compared to that of water. CuO – nanofluid line is lowering because at that day the radiation was not of good intensity.

Collector efficiency is function of mass flow rate and temperature difference. So, when temperature difference of CuO nanofluid increases, there is an augmentation in efficiency of the solar collector at same mass flow rate the, the reason of it being CuO-H_2O nanofluid having a good heat capacity when compared it to water. Now, if we are increasing rate of flowing fluid there can be seen an improvement in efficiency of that solar collector running on both water and nanofluid.

We can say according values that density of CuO nanoparticles is more in comparison to water, by this nanofluid increase the specific heat of the fluid than base fluid, resulting in increase in the efficiency of the collector. From the observation, it can be seen that at some time efficiency of water is more than that of nanofluid reason behind this is coagulation of nanoparticles at higher mass flow rates and mixing time of particles.

CONCLUSION

In current work main focus is upon experiment and various analysis of how DASC work when fluid is used as absorber. The conclusion of this work are given below:

1. Increment in the efficiency of the solar collector in the range of 4-6% by use of $CuO\text{-}H_2O$ nanofluid.
2. At 0.005% volume fraction of Nanofluid there is efficiency increment is by 2-2.5 % than that of volume fraction ϕ=0.05 nanofluid used.

At small particle size augmented in efficiency taken place, which cause it to an elevated heat absorption rate and leading in improvement in efficiency.

The utilization of nanofluids for sun based energy collector systems is a modern treand in engineering field, there is also available of various result and observation is available and in the same period various differences in results and principles used in application So, it is necessary to further theoretical as well as experimental work, investigations to increment efficiency of solar collector.

There, the conclusion is that the nanofluids having great potential is seen in solar thermal applications and they are best alternative the heat transfer limitation of conventional heat transfer fluid.

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