# EXPERIMENTAL INVESTIGATION OF FLAT PLATE COLLECTOR BY USING NANO FLUID

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***Abstract:*** In the present era, it is very essential to utilize the conventional energy sources. Alike, solar energy is similar type of, we can maximize the usage and store it for our daily use. As earlier the water was used as heat transfer medium in the flat plate collector, and their were so many disadvantage of using it. So, we are using nanofluid intead of it. So, in this research work, we have tried to maximize the efficiency and utilization of energy by keeping in mind the following parameters like solar tilt angle, inlet and outlet temperature, type of nano fluid used, area of collector, mass flow rate etc. The different data have been collected and calculated by performing experiment and best of them have been mentioned in it by analytical analysis. The result show that in comparision with water as absorption medium using the nanofluids as working fluid increase the efficiency.

***IndexTerms* - Flat plate collector, nano fluid, temperature, solar tilt angle, efficiency, useful heat gain.**

## I.INTRODUCTION

From the last few decades, we are facing the scarcity of natural resources like fossil fuels, minerals and much more. So, it becomes neccesary to preserve them and utilize them in proper way and rather use the renewable source of energy like solar energy, wind energy etc. Solar Energy is one of the major renewable source of energy and that can be used in many applications. It becomes necessary to collect the sun rays and energy in proper direction and use it in proper way. The major application of solar energy is in solar collector hot water providing systems. However, the low efficiency of solar flat plate collector is one of the major disadvantage of solar energy application. So, to increase and enhance the efficiency of collector is main area of interest for reseachers. Solar collector is a device which collect solar radiation and transfer to fluid passing in contact with it. While dealing with the collector we have to keep in mind the sun – earth basic angles, effect of different performance parameters etc. There are many different instruments to measure the solar radiation, we have used solar power meter in this work. Earlier water was used as absorbing medium in collector, but from recent advancement nanofluids are being used. Working fluid is one of the most critical parameter that effects thermal performance of flat plate collector. By using the nanofluid the thermal conductivity, heat transfer performance are higher compared to water. Studies in the literature generally related to the [1] applications of nanofluids in solar energy, [7] thermophysical properties of $Al_2O_3$ nanofluid and its effect on flat plate solar collector, experiment by using different nanofluids and their effect on collector [2,4,5,11,12].

## II.PROBLEM FORMULATIONS

The work of Tooraj Yousefi, Farzad Veysi, Ehsan Shojaeizadeh, Sirus Zinadini [2] throws the light on the experimental investigation on the effect of $Al_2O_3$ - $H_2O$ nanofluid on the efficiency of flat - plate solar collectors. In the present world, abundant amount of solar energy is being wasted. As, fuel prices and crises are being increasing day by day and it is our responsibility to save fuel and fossil fuels for future. Solar energy is also a renewable energy sources. Collectors are being used to collect the radiation coming from the source. Flat plate is simple type and most commonly used collector. As, earlier water was used as absorbing medium in it to transfer the heat. But there were certain heat losses, lower temperature, less efficiency and more environmental damage[1]. So, to overcome this promblems from last decades the nano fluids are being used as absorbing medium.

## III.RESEARCH METHODOLOGY

### 3.1 Experimental set – up

**Figure 1:** Pictorial view of the experimental setup

The experimental setup has been located at Dantiwada (Dist - Banaskantha) and experiment have been performed their. The value of latitude is 24.32° N and longitude is 72.33° E. Two identical collectors were used to make comparision of the results at same day and time. The experimental setup consists of flat palte collector and storage tank. The dimensions of the solar collector are 2m length, 1m width and 0.16m height. The collector is tilted at 27 degree from end towards the surface. The area of the absorber plate is 2m$^2$. The copper tube of 2.5cm outer diameter and 2cm inner diameter are used in the absorber plate. There are total 10 number of tubes. The thickness is of 0,5cm to reduce the loss of radiation. The capacity of tank is to store 50 litre of water and 100 LPD (litre per day) hot water. The inner tank is SS and outer tank also of SS powder coated. In between puffing is done of

50mm thick throughout the both tank. The solar radiation was measured with the solar power meter is shown in **fig 2**. The specification of collector shown in Table 3.1.1


**Figure 2:** Solar power meter for measuring solar radiation

Table 3.1.1: specification of flat plate collector

| Sr. No. | Parts | Material | Dimensions |
|---|---|---|---|
| 1 | Absorber Area | | $2 \times 1\ m^2$ |
| 2 | Header pipe & tail end pipe | Copper | 2.2cm & 2cm<br>t = 0.5mm<br>pitch range = 1cm |
| 3 | Glass Cover | Toughen glass | t = 4mm |
| 4 | Pipe | Copper | $D_o$ = 2.5cm<br>$D_i$ = 2cm<br>n = 10 |

### 3.2 Nanofluid Preparation

The material we have used for nanofluid is Aluminium Oxide ($Al_2O_3$) of reagent based grade. The commercial based $Al_2O_3$ with spherical – shape with 99.8% of purity and average diameter of 25nm was used. Triton X – 100 was naturally dispered surfactant in the solution of $Al_2O_3$. The distilled water was used as base fluid without salt content. If we have used water with salty content then their would be erosion and corrosion in the tubes, the life span would decrease of collector. For the preparation procedure of nanofluid, the 0.2% volume concentration of nanoparticles minutely dissolved in base fluid with distilled water and it form homogeneously an aqueous solution in **fig 3** as their are issues of its stability.

**Figure 3:** An aqueous solution of $Al_2O_3$ / $H_2O$ base fluid

Table 3.2.1: specification of $Al_2O_3$ nanofluid

| Parameters | Specification |
|---|---|
| Size of particle | 25nm |
| Shape of particle | Spherical |
| Colour and appearance | Aqueous solution |
| Volume Concentration | 0.2% |
| Density ($kg/m^3$) | 978 |
| Viscosity (Cp) | 0.825 |
| Thermal conductivity (W/mk) | 40 |
| Specific heat (J/g°c) | 4.026 |

### 3.3 Experimental Procedure

The experimental setup has been located at Dantiwada (Dist - Banaskantha) and experiment have been performed their. The value of latitude is 24.32° N and longitude is 72.33° E **.** These experiment were carried out in open air where there is no shading. The two identical flat plate collector were used for performing the experiment. The first collector was charged with pure water as base fluid and the other collector with $Al_2O_3$ – $H_2O$ basefluid. The experiment was conducted between 10:00AM to 3:00PM. The inlet and outlet temperature for both the cases were measured with non – contact XR thermometer. The solar radiation were measured by solar power meter as shown in **fig. 2.** The different data has been collected and has been used for analytical analysis/

### 3.4 Equations

Density of nanofluid is given by;

$$\delta_{n,f} = (1 - \phi)\, \delta_{bf} + \phi_{n,p} \quad (1)$$

Specific heat ($C_{P,nf}$) of nanofluid is given by;

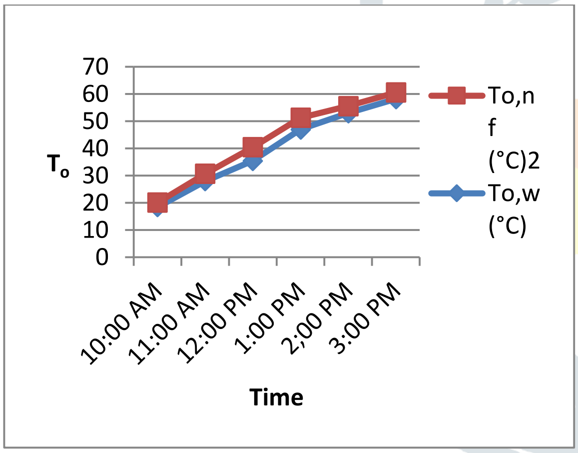
$$Cp, nf = \frac{[\,(1-\phi)\, \delta bf + \phi\, \delta np\, Cp,np\,]}{\delta nf} \quad (2)$$

$$Q = \dot{m} Cp \Delta T \quad (3)$$

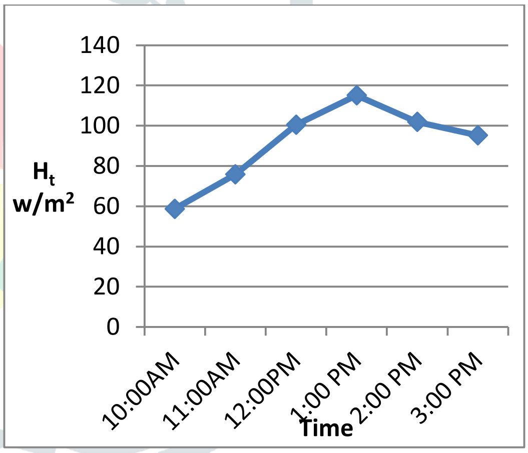
$$\eta = \frac{Q}{Ac\, Ht} \quad (4)$$

## IV. RESULT AND DISCUSSION

In **fig (a)** the comparision is done between the outlet tempeartures for both base fluids to time. In **fig (b)** the graph plotted for the hourly solar isolation radiation with respect to the time. In **fig (c)** the graph plotted for outlet temperature versus efficiency for water. In **fig (d)** the graph plotted for outlet temperature to efficiency for nanofluid. In **fig (e)** the comparision is done for both base fluid for efficiency to time.




(a)

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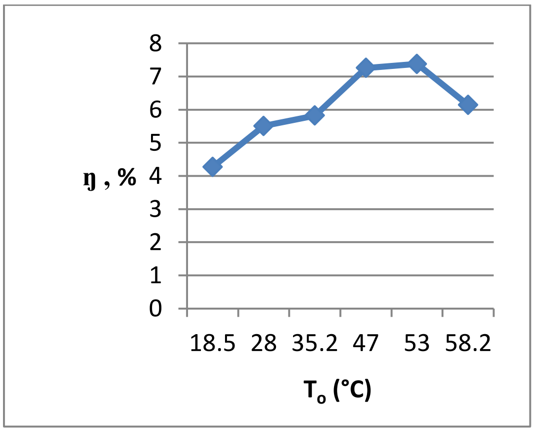
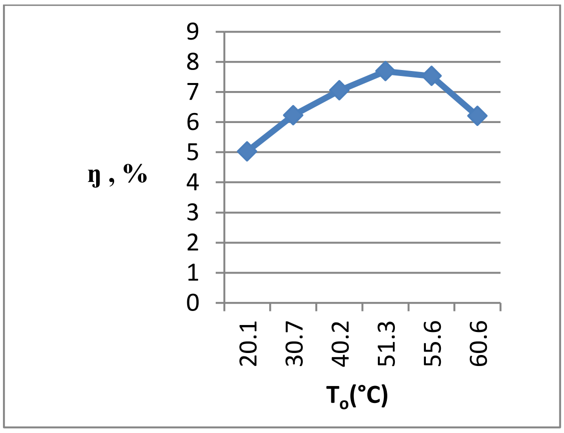
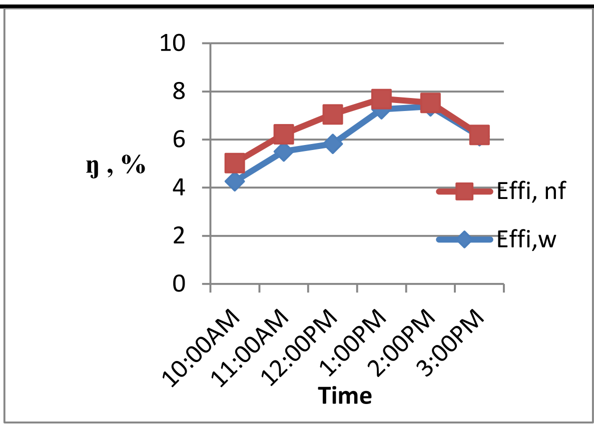



(c)




(d)




(e)

**Figure 4 :** (a) Outlet temperature versus time for both base fluids, (b) Hourly solar isolation radiation versus time, (c), (d), (e) effect of efficiency for both base fluids.

## V. CONCLUSION

After performing the experiment on flat plate solar water collector with $AL_2O_3$ – $H_2O$ nanofluid as base fluid, we concluded the following points-

- The outlet temperature $T_o$ (°C) of nanofluid is higher than the water as base fluid at each and every duration. The maximum outlet temperature measured for water and nanofluid are 58.2°C and 60.6°C
- The hourly solar isolation radiation falling on the collector decreases with the increase in length of time. The maximum solar radiation measured is 115.1 w/m$^2$ at 1:00PM
- For the relation between efficiency and time for both the base fluids. In case of water and nanofluid as base fluid the efficiency increases with time, but after some instant of time it tends to decrease. The maximum efficiency is obtained at 2:00pm for water and at 1:00pm for nanofluid.
- The useful heat gain calculated for each duration for both the cases, we can observe that heat gain collected for nanofluid base fluid is more than water base fluid
- As the outlet temperatures for both the cases increases with increase in time at some extent and then decrease. The maximum efficiency is obtained at 53°C at 2:00pm for water and maximum efficiency is obtained at 51.3°C at 1:00pm for nanofluid.
- The future scope of this research is we can also use naofluids in various applications like – solar cells, thermal energy storage, solar still etc.

## VI. ACKNOWLEDGEMENT

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## REFERENCES

[1] Omid Mahian, Ali Kianifar, Soteris A, Kalogirou, Ioan Pop, Somchai Wongwises, "A review of the applications of nanofluids in solar energy", Iternational Journal of Heat and Mass Transfer 57 (2013) 582-594

[2] Tooraj Yousefi, Farzad Veysi, Ehsan Shojaeizadeh, Sirus Zinadini, "An experimental investigation on the effect of $Al_2O_3$ - $H_2O$ nanofluid on the efficiency of flat - plate solar collectors", Renewable Energy 39 (2012) 293-298

[3] Faruk Kiliça, Tayfun Menlikb, Adnan Sözenb, "Effect of titanium dioxide/water nanofluid use on thermal performance of the flat plate solar collector", Solar Energy 164 (2018) 101-108

[4] Ramesh R, Dr. P. Arulmozhi, Sathiskumar M, "Experimental Analysis of Flat Plate Solar Water Heater using Cerium Oxide / Water Nano Fluid Under Forced Convention", International Journal of Engineering Research & Technology, 2278-0181

[5] Z. Said, M.H. Sajid, M.A. Alim, R. Saidur, N.A. Rahim, "Experimental investigation of The Thermophysical Properties Of Al2O3 -Nanofluid And Its Effect On A Flat Plate Solar Collector", International Communications in Heat and Mass Transfer (2013)

[6] Amirhossein Zamzamian, Mansoor KeyanpourRad, Maryam KianiNeyestani, "An experimental study on the effect of Cu – synthesized/EG nanofluid on the efficiency of flat plate solar collectors", Renewable Energy 71 (2014) 658 – 664

[7] Saleh Salavati, Ali Kianifar, Hamid Niazmand, Omid Mahian, Somchai Wongwises, "Experimental ivestigation on the thermal efficiency and performance characteristics of a flat plate collector using $SiO_2$/EG-water nanofluids", International Communications Heat and Mass Transfer 2015

[8] Sujit kumar vermaa, Arun kumar tiwarib, Sandeep tiwaric, Durg singh chauhana, "Performance analysis of hybrid nanofluids in flat plate solar collector as an advanced working fluid", Solar Energy167 (2018) 231-241

[9] R. Saidur, C. Meng, Z. Said, M. Hasanuzzaman, A. Kamyar, "Evaluation of the effect of Nano Fluid based Absorbers on Direct Solar Collector", International Journal of Heat and Mass Transfer 55 (2012) 5899-5907