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PERFORMANCE INVESTIGATION OF DISTILLATION SYSTEM COUPLED WITH PARABOLIC TROUGH COLLECTOR (PTC) AND NANOFLUID USED AS WORKING FLUID

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ABSTRACT

Day to day the demand of potable water is increasing. Desalination is one of economical process to get pure water using renewable source of energy. Many researchers are working to enhance the performance of the conventional desalination plant. This paper is based on the experimental work carried out to increase the yield using parabolic trough collector (PTC) coupled with conventional solar still plant.To trap maximum amount of solar energy Al_2O_3/Water nanofluid is used in PTC. The experiment is carried with 0%, 0.05% and 0.1% volume fraction of Al_2O_3water based nanofluid as a working fluid in PTC to compare its performance with conventional still plant. The result shows that coupled system gives 66% more yield as compare to the conventional desalination plant.

Keywords: *Solar distillation; Parabolic trough collector; Nanofluid.*

I. INTRODUCTION

Availability of potable water is the crucial issue to survive the life on the earth. So since last many decades peoples are working on designing the systems to get the fresh water from the plenty of salty water sources available on the earth like sea and the ocean. Desalination is one of the popular and economical methods to convert saline water into fresh water using solar energy. The conventional single slope 1sq. m still solar still plant gives very less yield, approximately 300 ml for using active heating [1].

Nanofluid is a advanced heat transfer fluid which has high thermal conductivity compare to the conventional heat transfer fluid. As the volume fraction of the nanoparticles used increases the thermal conductivity will also increases[2].

By adding the nanoparticles in the saline water researcher studied the performance of the still plant. As the conductivity of the saline water is increased because of nanoparticles used the efficiency of the plant is also increased. Using Al_2O_3 nanoparticles 51.35 % increase in yield is observed by Madhu in their experimental investigation[3]. But it is observed in many study nanoparticles also migrate with the fresh water.

So instead of adding the nanoparticles direct adding in the salty water many people studied the performance of the still plant coupled with flat plate collector, parabolic trough collector using nanofluid as working fluid. The solar heat is trapped by the nonofluid using flat plate collector or parabolic trough collector (PTC) and then that heat is given to the saline water by passive heating. The increment in the yield using the solar still with coupled system studied by different researchers is shown in table 1.

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Table1. Effect of Nano fluid on the performance of still

Author	Nano particles	Volume fraction (%)	Particle size (nm)	% Increment in Yield	Results and discussion
Sahota, Shyam, & Tiwari, 2017 [5]	Al_2O_3 TiO_2 CuO	0.143-0.273 0.059-0.187 0.044-0.153	—	19.10 10.38 5.25	Most extreme profit accomplished by utilising Al_2O_3 nanoparticles
Madhu, Bala Subramanian, Nagarajan, Sathyamurthy, &Mageshbabu, 2017[6]	Al_2O_3 TiO_2 CuO	0.05,0.1, 0.2	25	74.19 50.23 53.54	As the volume devision expanded the yield is expanded.
Sharshir et al.,2017[7]	Copper oxide Graphite microparticles	0.125-2	1000 1250	47.80 57.60	It is discovered that distillate yield increased as volume division of nanofluid increased.
Kabeel, Omara, & Essa, 2014[8]	Cu_2O Al_2O_3	0.02 – 2.0	10 - 14	133.64 125.0	By giving vacuum in basin the profit we get is more than without vacuum.
Kabeel, Omara, & Essa, 2013[9]	Al_2O_3	0.2	—	116	By operating a fan or providing vacuum we can get high productivity.

PTC is very impactful on the monthly pure water production of the desalination plant in comparison with flat plate collector because PTC has high efficiency[4].This paper designates results of distillate yield for the active solar desalination system using PTCwith Al_2O_3/Water nanofluid as working fluid.

II. EXPERIMENTAL SETUP

Experimental rig consist of 1 Sq. m solar still plant placed at North-South orientation. The solar still is coupled with PTC. For each scenario of the experiment 25 lit saline water is filled in the basin. To trap maximum amout of solar radiation through PTC Al2O3/water Nanofluid is used as a working fluid. The hot nanofluid is then pumped to the still where it dissipates the heat to the saline water. The J- type thermocouple is used to measure the inlet and outlet temperature of nanofluid at PTC. Pyrometer is used to measure the solar radiation intensity. Experiments are conducted considering the four scenarios are as under:

1. Performance of Conventional solar still
2. Performance of Solar still coupled with PTC and water as a working fluid.
3. Performance of Solar still coupled with PTC and 0.05% Al_2O_3/water nanofluid as a working fluid.

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4. Performance of Solar still coupled with PTC and 0.1% Al_2O_3/water nanofluid as a working fluid.

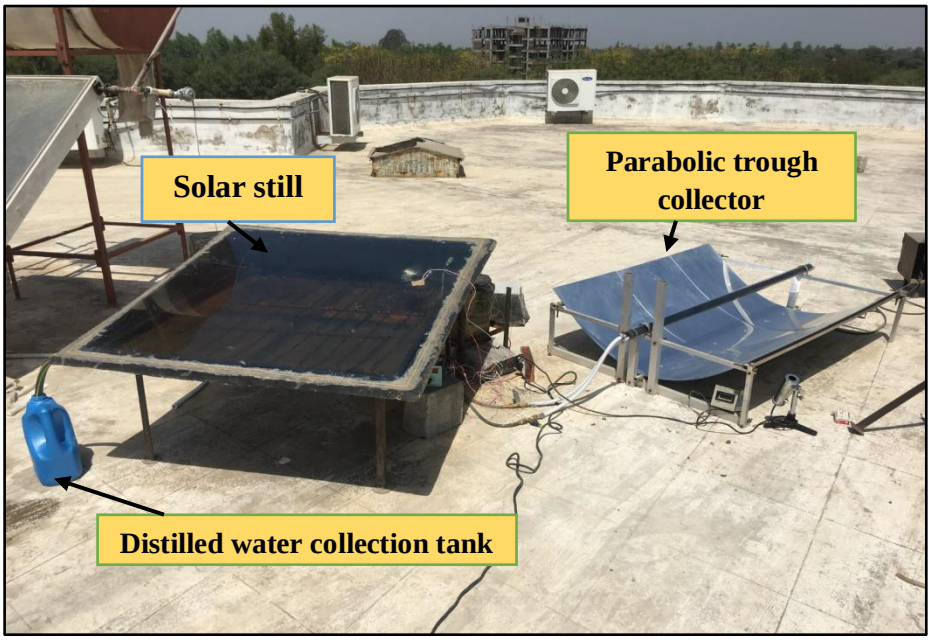

Figure 1. Experimental setup

To prepare the nanofluid two step method is used. Ultrasonic agitation force is used to synthesis the stable nanofluid using Probe sonicator. To enhance the stability 1% volume fraction of Oleic acid is used while agitation.

The heat absorbed by the saline water and the thermal efficiency of the still plant is calculated as:
Total heat output from the system = $m_f \times h_g$
Where, m_f = mass of distilled water in kg
h_g = Enthalpy of generated steam in J/kg
Total heat input to the system = I×t×A
Where, I = Solar radiation in W/m^2
T = Time in second
A = Area of the basin m^2
Thermal Efficiency of the system (η_{th}) = $\frac{mf \times hg}{I \times t \times A} \times 100$

III. RESULTS AND DISCUSSION:

From the experimentation it is observed that the cumulative yield can be increased using the coupled still plant as shown in Figure 2. The maximum yield is found 1747 ml in still plant coupled with PTC in which 0.1 & Al2O3/water is used as a working fluid.

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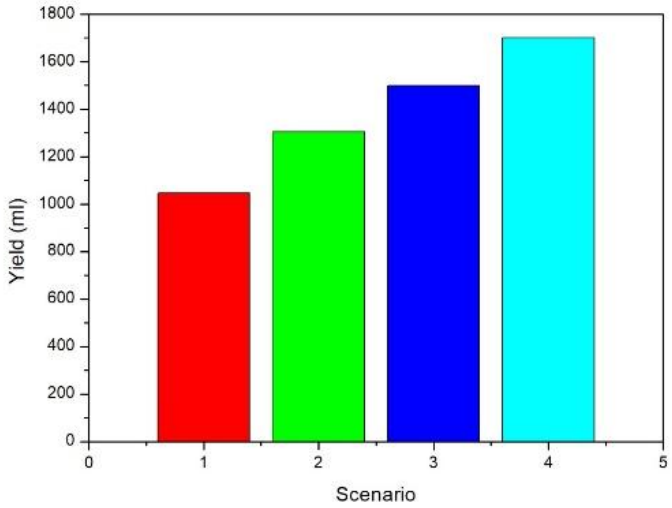

Figure 2. The maximum cumulative yield for different Scenario

It is observed that the efficiecy of the plant is maximum at time between 2 pm to 3 pm as shown in Figure 3 for all scenario.

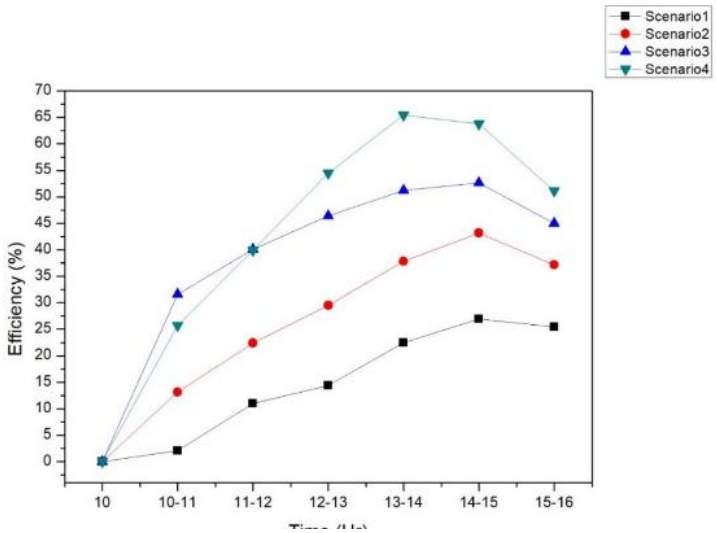

Figure 3. Maximum Thermal efficiency of still with respect to time

IV. CONCLUSION

This work has carried out to investigate the performance of solar still coupled with PTC. In this research potential of Al_2O_3/water nanofluid in PTC is also studied. Some of the important findings of this research work are as below:

- Maximum increase in the yield is 66% as compared to conventional solar distillation system (1 Sq. m). It is observed in scenario 4(solar distillation system coupled with PTC and working fluid as an Al_2O_3/water nanofluid with 0.1% volume fraction.)
- Solar distillation system coupled with PTC system shows the enhancement in thermal efficiency of distillation plant.

- It is found that as the volume concentration increases the thermal efficiency of coupled distillation system is also increases. The Maximum thermal efficiency of 69.48 % obtained in scenario 4.

V. ACKNOWLEDGEMENT

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