Experimental Study of Masonic Solar Still by Using Nanofluid

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ABSTRACT— This paper presents an experimental study of effect of nanofluid on performance of masonic solar still. Two different nanoparticles i.e. Al_2O_3 and CuO are used at 0.1%, 0.2% and 0.3% concentration. It was observed that productivity of solar still is increased by the use of nanofluid. Productivity of solar still is checked in between 12pm to 3pm at peak sunshine period. It shows increase in productivity by increase in concentration of nanoparticles in base fluid. Al_2O_3 gives best result at 0.3% concentration i.e. 45.19% rise in yield and CuO gives 89.42% rise in productivity at 0.3% concentration. On comparison of nanofluids CuO shows better results than Al_2O_3.

Keywords— Masonic solar still, Nanofluids, Yield,Al_2O_3,Cuo,

I. INTRODUCTION

In the current scenario there is a rapid increase in demand of drinking water and sources of pure water are unable to achieve the demand for supply. Though earth is covered by 73% of water but out of 100% water 97% water is saline or salty water. So only 3% water is potable but out of which 2% is in ice form. So now only 1% of water is useful. This water is available in lakes, ponds, rivers and below the earth's surface.

Now to meet this deficiency of water saline water needs to be purified and should made potable. But the cost for osmosis and other techniques of purifying water are so high and energy consuming.Solar still is a device which uses solar energy to purify the water. This distillation technique was known long time ago. This works on principle of evaporation and condensation. Water at the basin gets evaporated by solar energy and condensate on inner surface of inclined glass. This condensate then trickle down and is collected though channel. Solar still which is does not use external power supply are called as passive solar still and those still who gets hot feed water by means of other power supply are called as active solar still.

Solar still is studied by different aspects to increase its performance. Different types of solar still with different shape, angle of inclination and area and observed that solar still with symmetric double slope. The inclination angle of 45^0 and lesser inner surface area gives best productivity(A .Y. Hashim et.al. 2010). By increasing wind speed from average speed 1.2 m/s to 4.5 m/s there is increase in the production by 15.5%. And also cooling of glass by sprinkles after 10min interval gives 31.8% more yield(Husaham M. Ahmed et. al.2012). The effect of applying vacuum on yield of solar still showed that yield could be increased by 100% when considering complete vacuum(Al–hussaini et. al.1995).

The performance of adding dyes at basin water increases the daily yield and efficiency of the system about 10% (Dutt et. al.1989). The comparison of bet black granite basin solar still and iron solar still showed that the productivity of solar still was better for black granite basin solar still than iron steel basin solar still (JadhavMadhav V. 2011).Preheating the water entering the still increases the water productivity by amount about 27.7% - 29.3%. anddecreasing the pressure inside the still using vacuum pump improves the solar still productivityby amount about 21.8% - 23.9%(A. S. Zedan et. al. 2015). The productivity of solar still increases due to nanoparticle mixed in black paint, at basin, is significant at 95% confidence interval (M. K. Sain et. al. 2015)

Solar still is very cheap and energy efficient device for producing distilled water from saline water but the major drawback of this system is its productivity which is very low as compared to the demand hence number of attempts were made to increase its productivity.As discussed above there are number of researches done on solar still. This paper includes the experimentation of use of different nanofluids at different concentration in masonic solar still. Masonic solar still is rigid construction so it has very low maintenance cost. It can withstand against bad weather conditions also.

Experimental setup

The solar still is made up of bricks, sands, cement etc. The inner surface of still is coated by tiles. To avoid leakages, heat loss and to capture more solar radiations internal area of still is lapped with black resin. Top surface of solar still is covered with the glass of 5mm thickness. It is inclined at 18.5^0. Angle is almost equal to latitude of pune i.e. 18.5204^0, which is optimum angle for maximum output. Trickled water droplets or condensate are collected through a channel provided at the end of the inclined glass. To avoid settling of nanoparticles wiper is mounted at basin. Fig 1 shows the actual experimental setup. It has been provided with opening at the wall for pouring the nanofluid or saline water at basin. Setup is fully airtight so that no vapors will escape to atmosphere due to rise in pressure inside the basin. The output from still is collected in bottle and then measured by measuring cylinder.

Fig.1 Experimental setup

Preparation of Nanofluid

In this experiment two different nanofluids are used at three different concentrations. Al_2O_3 and CuO nanofluids are used at 0.1%, 0.2% and 0.3% concentration. Nanoparticles are insoluble in water so it require sonication. Nanofluids are prepared by two step methods. First 3 lit. of water taken as base fluid. Then nanoparticles are added to it as per the required concentration. After that, magnetic stirring is used to mix the particles in base fluid. Then the conical flask containing solution is kept onultra-sonicationdevice for sonication. It takes almost 45 mins to 1 hour for preparation of nanofluid of one batch. No dispersant is added to increase the stability because it may evaporate along with water and condensate will not be potable any more.Even some of the dispersants lead to increase the boiling point of nanofluid which is not desirable in case of solar still experimentation.

In fig 2.the device is shown which was used for ultra-sonication. Conical flask containing mixture of base fluid water and nanoparticles are put into the ultrasonicator. Heater coil is kept on to achieve the require 45^0c to 50^0c temperature which is necessary for good sonication.

Stability of oxide nanoparticles is very less as compared to pure metal nanoparticle. Stability of this prepared nanoparticle is checked. These nanoparticles settle down within 12 hours.

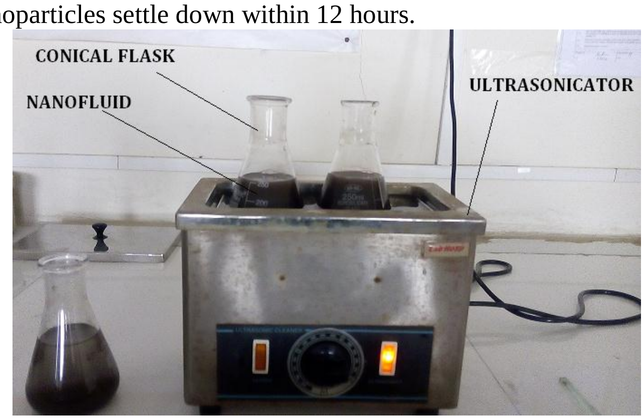

Fig.2Ultrasonicator for preparation of nanofluid

Spalding's Mass Transfer Theory for Distillate Output

The bulk state of the mixture of air and water vapors in the solar still is referred to as G-state, while the mixture close to an evaporating surface (water surface) is referred to as S-state (Fig.1). It can be assumed that the saturation condition exists at S-state. A flux g* of the moist air at the G-state moves towards S-surface, induces mass flux from theS-surface and the total flux (+g*) at the S-state moves through the G-Surface away from the interface. The flux g* is called the Reynolds flux or mass transfer conductance. An expression for g* with different orientations of the absorbing surface is given (Indaba, 1984)

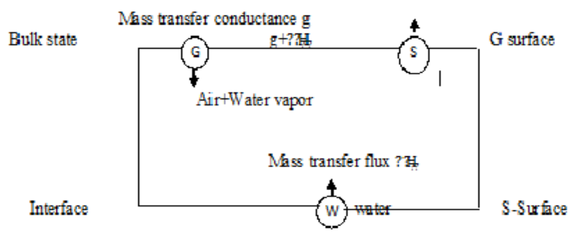

Fig.3 Mass transfer mode (after kiatsiviroat et.al.1986, 1987)

Orientation	Nu	g*.H.Sc/ µf	Range
Horizontal(θ=0)	$0.14(Gr.Sc)^{1/3}$	$0.54(Gr.Sc)^{1/4}$	$4.2\times10^5 < Gr < 4.2\times10^8$

Limitations of Spalding's Mass Transfer Theory

In Spalding theory, wet bulb temperature and dry bulb temperature of air in still are to be measured before calculating theoretical yield i.e. distillate water. As per dry bulb temperature and wet bulb temperature concept it is not possible to measure both temperatures inside the still basin.

Results and discussion

The experiment was carried out on passive type of solar still. Prepared nanofluid was poured at basin at 11pm and readings taken from 12-3pm at the interval of 1 hour. Results and graphs obtained are mentioned below.

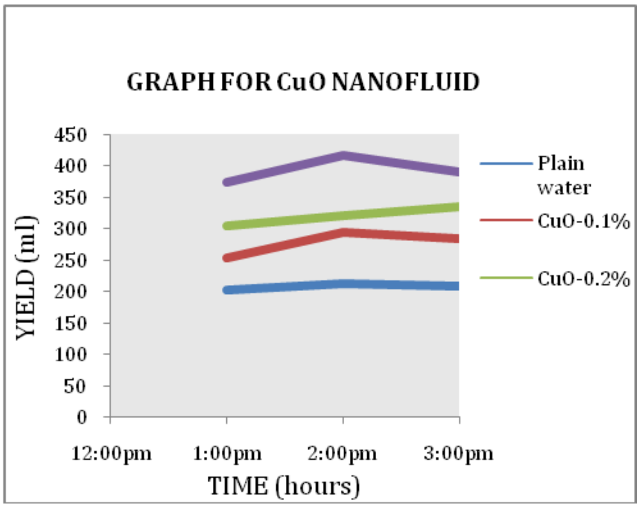

Fig.4Variation in yield for different concentrations of CuO nanofluid and plain water

For plain water average yield of 3 hours at peak sun shine period i.e. 12pm to 3pm is 208 ml/hr. Using CuO nanofluid for 0.1% concentration average yield is 278 ml/hr. For 0.2% concentration average yield is 321 ml/hr. and for 0.3% concentration average yield is 394m ml/hr. It can be seen that there is rise in productivity for solar still i.e. 33.65%, 54.32% and 89.42% respectively for different concentrations of nanofluid.

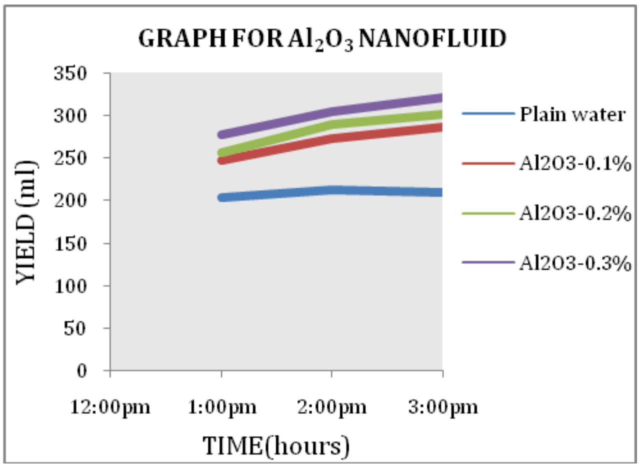

Fig.5Variation in yield for different concentrations of Al_2O_3 nanofluid and plain water

Now fig.4 shows the graph for Al_2O_3. Using Al_2O_3 nanofluid for 0.1% concentration average yield is 269 ml/hr. for 0.2% average yield is 282 ml/hr. and for 0.3% average yield is 302 ml/hr. It shows that there is increase in productivity due to use of nanofluid i.e. 29.52%, 35.57% and 45.19% at different concentration respectively.

II. CONCLUSION

These are the conclusions made on results:

1. Increase in evaporation at masonic solar still by the use of nanoparticles at basin water due to increase in thermal conductivity and raised temperature of water.
2. The maximum increase in productivity by CuO is 89.42% at 0.3% concentration and by Al_2O_3 is 45.19% at 0.3%.
3. On comparison of two nanofluids i.e. Al_2O_3 and CuO the results are better for CuO than Al_2O_3

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