

Experimental Study of Performance of Conical Solar Still Using Nano fluid

Prof. Vishal Jadhav¹

Mechanical Engineering Department, P K Technical, Campus, Savitribai Phule Pune University, Pune
Email: vishaljadhav.tech@gmail.com

Abstract- The world requirement for potable water is increasing steadily with growing population. Desalination of Water using solar energy is suitable for potable water production from brackish and seawater. Many researches and development works tried to enhance the productivity of solar stills using different methods. So this work focuses on the productivity enhancement of solar still by decreasing the shadow effect for maximum utilization of solar radiation by using conical solar still. A conical solar still is manufactured & its performance is studied by using parameters like depth of water in basin, day time, basin water temperature, heat transfer coefficient, solar radiation, etc. To improve performance of conical solar still the Nano fluid of copper oxide is added to basin water in % of 0.1 & 0.05. The performance of solar still will be compared with & without Nano fluids. The Yield per hour is measured & daily efficiency is been calculated.

Index Terms- Solar Still, Nano fluid, Productivity, Daily Efficiency

1. INTRODUCTION

Distillation is one of the many available processes for water purification, and sunlight is one of several forms of heat energy that can be used to power that process. To dispel a common belief, it is not required to boil water to distill it. Simply increasing its temperature, short of boiling, will adequately increase the evaporation rate. In fact, though vigorous boiling quickens the distillation process, it forces unwanted residue into the distillate, defeating purification.

Distillation requires an energy input as heat, electricity and solar radiation can be the source of energy. When Solar energy is used for this purpose, it is known as Solar water Distillation. Solar Distillation is an attractive process to produce portable water using free of cost solar energy. This energy is used directly for evaporating water inside a device usually termed a "Solar Still". Solar stills are used in cases where rain, piped, or well water is impractical, such as in remote homes or during power outages.

The use of solar thermal energy in desalination applications has so far been restricted to small-scale systems in rural areas. The reason for this has mainly been explained by the relatively low productivity rate compared to the high capital cost. However, the coming shortage in fossil fuel supply and the growing need for fresh water in order to support increasing water and irrigation needs, have motivated further development of water desalination and purification by renewable energies.

2. LITERATURE REVIEW

H.E. Gad designed & manufactured a conical solar still of base area 0.8m² & of cover of solar still inclined at 31°. Heat transfer coefficients were estimated. The experimental results of conical solar still was compared with conventional solar still having same base area. Results show that the daily productivity of 3.38L/m² & 1.93L/m² for conical & conventional solar still respectively. Analogy between heat & mass transfer investigated from dimensionless parameters (Gr, Sh, Pr, Sc, Nu).

H.E. Gad studied the performance of conical solar still in Egyptian condition. The measurements of ambient temperature, basin temperature, water temperature, cover temperature, distillate output, total solar radiation intensity, wind speed were recorded. Thermal distillation efficiency & daily efficiency was calculated. Maximum daily efficiency was 32.18%.

Badawi W. Tleimat did comparison of plastic & glass condensing covers for solar distillers. It is found that the productivity of plastic cover still is less than that of glass cover still. But the use of plastics permits a much wider choice of geometrical configuration than glass. The factors of major importance in designing for the use of plastic films are its flexibility & its high thermal expansion coefficient.

Ismail designed & manufactured a transportable hemispherical solar still. The daily productivity of water was in range of 2.8L/m² to 5.7 L/m². The experiment was carried for 6 days in which readings of saline water temperature, still cover temperature, ambient temperature, solar radiation, wind speed, distillate yield with respect time of day were recorded. The maximum daily efficiency with respect to saline water depth was 33%, as depth increases daily efficiency decreases. Maximum still efficiency was 59.8% at 13th hour of day 5.

Himanshu Manchanda have done review & analysis on designs & performance parameters of passive solar still. Various designs of solar stills are provided. Effect of water depth & condensing cover, effect of dyes, effect of sun tracking system, effect of internal & external reflectors, effect energy storage & phase change materials, effect of flow rate, effect of condensing cover cooling, effect of nanofluids, effect of insulation on performance of solar still is discussed. Also cost analysis of solar distillation system is given.

V. K. Dwivedi, experimently validates the internal heat transfer coefficients in passive solar still by different thermal models. Rate of convective heat transfer & evaporative heat transfer were calculated. The two stills single slope & double slope were manufactured. The thermal models used were Dunkel"s model, Kumar &Tiwari model, Chen etal."s model, Adhikari et al."s model, Zheng at al."s model, Clark model"s. Even the value of convective heat transfer coefficient obtain from Dunkel"s model is less, it was use for calculation because of low percentage error. Convective heat transfer coefficient for single & double slope still was 1.463W/m^2 & 1.923W/m^2 , evaporative heat transfer coefficient for single & double slope still was 8.837W/m^2 & 8.19W/m^2 respectively. Productivity of still decreases for various water depths.

OmidMahian has done review on application of nanofluids in solar energy. The review mainly consist of effect of nanofluids on the efficiency improvement of solar collectors. Other application of nanofluids in thermal energy storage, solar cell, solar stills are also review. The challenges in using nanofluids are discussed.It is suggested that the nanofluids in different volume fraction & particle size should be tested.

M. KoilrajGnanadason manufactured a solar still. Basin made of copper & glass plate angle was 32° .The carbon nanotubes are used as nanofluid to increase heat transfer raal conductivity of nanofluid is measured by transient hot wire method. To increase the rate of evaporation of water vacuum is created inside solar still by vacuum pump so boiling of water takes place at 60°C . Various operating conditions such as water depth, insulation thickness, ambient temperature, salt concentration with & without nanofluid were considered. The variable glass temperature, water temperature, ambient temperature, productivity measured hourly. Efficiency of still increased by 60% due to vacuum created & by 50% due to nanofluids. Combine efficiency increased was found to be 150%. The average daily output was found to be 4liters/day.

A.E Kabeel did design, fabrication of two solar stills of same specifications. One is conventional & other is modified solar still. In the modified solar still vacuum pump & condenser were installed. The performance of modified solar still was studied for constant & variable fan speed. The performance of conventional solar still was increased by adding aluminum oxide nanofluid. It is found that productivity of conventional solar still increased by 76% due to nanofluid. With nanofluids& vacuum pump daily average productivity estimated was 6lit/day.

3. PROBLEM STATEMENT

A conventional basin type solar still is simply an air tight basin that contains a shallow layer of saline water, a sloped top cover of a transparent material usually glass and side metal frame walls. The cost of building and operating a conventional still is relatively low compared to those involving sophisticated designs. However, the conventional or standard basin type solar still proven to have a low thermal efficiency with low daily distillate productivity.

The efficiency and yield of the conventional solar still depend on different factors: the design and functionality of the still, location, weather conditions, etc. Their low thermal efficiency is due to the considerable shadow caused by the walls of the basin that tend to decrease the absorption of solar radiation that could have been used for water distillation process.

Rate of evaporation of basin water is one of the factor on which productivity of still depends. As the rate of evaporation of water is depends on conductivity of base fluid. The base fluid used will be water which will have less conductivity & hence low evaporation rate.

4. AIM & OBJECTIVE

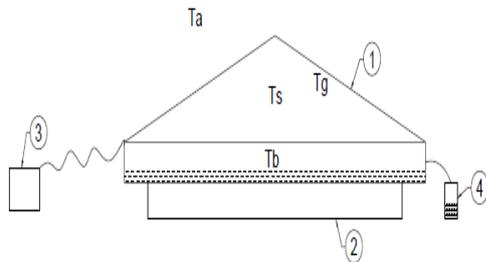
In this project, aim is to be identify the method to improve thermal efficiency of solar still by decreasing shadow effect & to increase the time for absorption of solar radiation. Also the parameters which affect the p productivity of solar still are studied. To identify the way by which rate of evaporation will be increased.

Objectives of this project are,

1. To study various parameter affecting productivity of solar still.
2. To manufactured conical solar still setup for experimental study.
3. To study productivity of solar still performance considering various parameters.

4. To study effect of Nano fluid on performance of solar still
5. To calculate daily efficiency of solar still.

5. CONSTRUCTION



1. Glass Frame
2. Base Frame
3. Temperature Indicator
4. Measuring Flask

Fig. 1 Line Diagram of experimental setup

The Experimental setup is shown in fig.2



Fig 2. Experimental setup of conical solar still.

The base frame of solar still is fabricated by Mild Steel sheet if 3.12mm thick. The Base frame is of circular plate is of diameter 1100mm. Water basin is formed on base frame by welding 900mm diameter welded ring of 50mm height, at the top to store water. The support of base frame is of 50 mm height as shown in fig. The base plate is been black painted to absorb maximum amount of solar radiation so evaporation can be increased. The themocol is used for insulation purpose to avoid heat loss to surrounding

Glass frame allows to transmit all the solar radiation incident on it to water. The shape of glass frame is conical which will minimized the shadow

effect which is observed in other conventional still. Angle of tilt is 200 to get maximum intensity of solar radiation, which is calculated according to latitude of Pune (18.55 N). The base diameter of cone is 1010mm & diameter of top is 128 mm & height of cone is 210mm.

Temperature of ambient air, basin water temperature, temperature of space inside solar still, & glass temperature are measured by using thermocouples PT100. To measured temperature of basin water & glass silicon coated thermocouples are used. Thermocouples are connected to universal temperature indicator.

6. NANO FLUID.

As rate of heat transfer will depend on thermal conductivity, it is found that the conductivity of conventional fluid like water is less than that of metals. In solar still as working fluid is water its thermal conductivity is low. Hence the thermal conductivity can be increased by introducing metal particle in it. Now new approach is to introduce Nano metal particle in water. The nanoparticles changes the transport properties & increases the heat transfer rate of water. Such fluid with solid nanoparticles suspended in liquid is called Nano fluid.

The Copper oxide is Nano fluid used since it it having more thermal conductivity value than other materials, The Nano fluid is prepared by two way method. The Nano fluid added in % of 0.05 & 0.1% .

7. EXPERIMENTATION

The experiments were carried out between 9 am to 6pm from 1 may 2017 to 12 may 2017. During experimentation observations of basin water temperature, glass surface temperature, temperature of space inside the still, ambient temperature, yield were taken at each hour. Data of solar radiations taken from Automatic Weather station, Indian Meterological Department, Pune. During experimentations all above observations are made for basin water depth of 1cm, 3cm, 5cm & % of nanofluid is varied to 0%, 0.05%, 0.1%.

To study the performance of solar still following parameters were considered.

1. Temperatures(Basin water, Glass, Space, ambient)
2. Day Time
3. Solar Radiations
4. Daily Yield
5. Daily Efficiency
6. Amount of Nano fluid added
7. Depth of water in basin

8. RESULTS

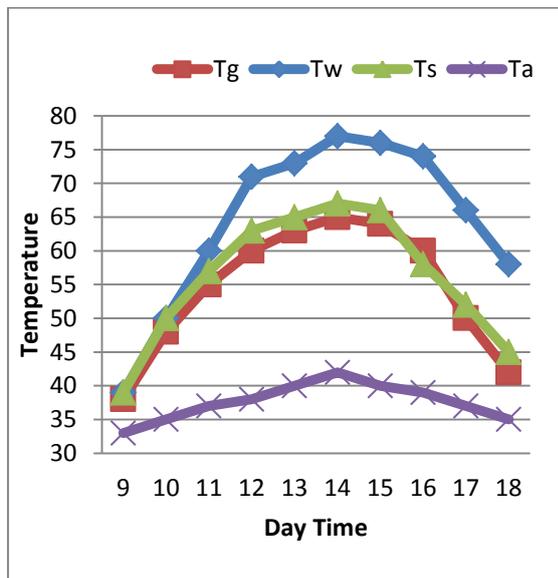


Fig. 3 Variation Of Tw, Tg, Ts, Ta for 1cm water depth without nanofluid.

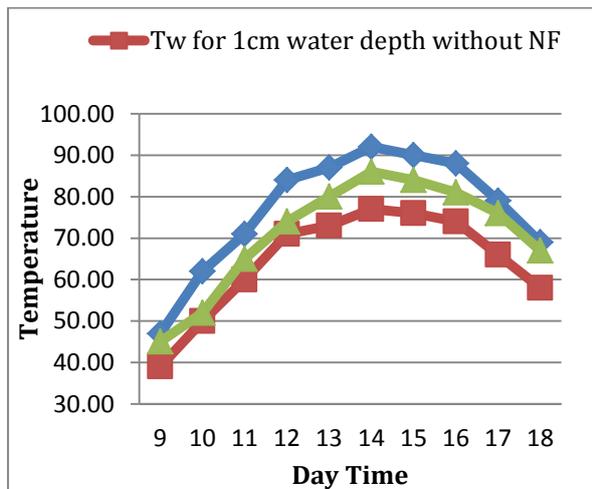


Fig. 4 Variation of temperature vs day time for nanofluid % from 0%, 0.05%, 0.1% for 1cm water depth.

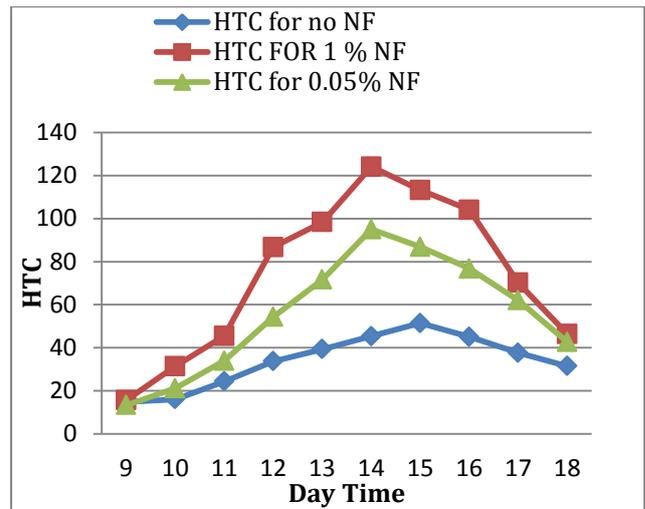


Fig. 5 Variation Of Heat Transfer coefficient vs day time for Nano fluid % of 0%, 0.05%, 0.1% for 1cm water depth.

Table 1 Daily Efficiency for various water depth & % of Nano fluid

Sr No.	Depth of water	Daily Efficiency %		
		No NF	0.05% NF	1% NF
1	1 cm	9.74	10.54	13.43
2	3 cm	6.64	7.51	9.56
3	5 cm	5.16	6.08	6.65

Table 2 Daily Yield for various water depth & Nano fluid %

Sr No.	Depth of water	Daily Yeild (Lit/day)		
		No NF	0.05% NF	1% NF
1	1 cm	2.19	2.45	2.80
2	3 cm	1.45	1.59	1.89
3	5 cm	1.19	1.30	1.46

9. CONCLUSION

From the results obtained following conclusions can be drawn, The productivity & daily efficiency of solar still increases with increase in % of Nanofluid. The maximum yield obtained is 2.81 lit for a day. As depth of water increases productivity of still decreases. Also, maximum efficiency occurs when depth of water is minimum. As adding nanofluid in basin water in solar still

increases the performance of solar still it can be solution to less efficiency of conventional solar still.

REFERENCES

- [1]. H. E. Gad , Sh Shams, El- Din, A. A. Hussein, Kh. Ramzy, (2015), "Thermal analysis of a conical solar still performance: An experimental Study", *Solar Energy* 122, 900-909
- [2]. H. E. Gad , Sh Shams, El- Din, A. A. Hussein, Kh. Ramzy, (2013), Performance of a conical solar still under Egyptian condition, , *ICFD11-EG-4114*.
- [3]. Badawi W. Tleimat, Everett Howe, (1968), Comparison of plastic & glass covers for solar still distillers, *Solar Energy*, Vol.ume 2, 1969.
- [4]. Basel I. Ismail, (2009), Design and performance of a transportable hemispherical solar still, *Renewable Energy*, 145-150.
- [5]. Himanshu Manchanda* and Mahesh Kumar, (2015), A comprehensive decade review and analysis on designs and performance parameters of passive solar still, *Renewable :- Wind, Water, Solar Energy*, 2/17
- [6]. Abdul Jabbar N. Khalifa,(2011), On the effect of cover tilt angle of the simple solar still on its productivity in different seasons and latitudes, *Energy conversion & management*, 52, 431-436.
- [7]. V.K. Dwivedi, G.N. Tiwari (2009), Comparison of internal heat transfer coefficients in passive solar stills by different thermal models: An experimental validation, *Desalination*, 246, 304-318.
- [8]. Omid Mahian, Ali Kianifar, Soteris A. Kalogirou, Ioan Pop, Somchai Wongwis,(2013), A review of the applications of nanofluids in solar energy, *International Journal of Heat and Mass Transfer*, 57, 582-594.
- [9]. M. Koilraj Gnanadason, P. Senthil Kumar, S.Rajakumar ,M H. Syed Yousuf, (2011), Effect of nanofluids in a vacuum single basin solar still, *Studies International Journal of Advanced Engineering Research*. , Volume I , 171-177
- [10]. A.E. Kabeel, Z.M. Omara, F.A. Essa,, (2014), Enhancement of modified solar still Integrated with external condenser using nanofluids: An experimental approach, *Energy conversion & management*., 78, 493-498