Use of a new technique of nano-fluids to increase the solar still productivity

Abdelhamid LABIAD,
Laboratory (PEL),
University Kasdi Merbah
Ouargla, Algeria,
Email: midouh86@gmail.com

Mohammed H. SELLAMI,
Laboratory (PEL),
University Kasdi Merbah
Ouargla, Algeria
Email:

Ridha. CHERRAYE,
Laboratory of New and Renewable Energy in Arid Zones (LENREZA),
Kasdi Merbah University of Ouargla, Algeria,
Email: cherrayeridha@yahoo.fr

Zine Elabidine BENARIMA,
Process Engineering Laboratory (PEL),
Université des Sciences et de la Technologie Houari Boumediene, Algeria,
Email:

Abstract— **Potable water is essential to life. The supply of fresh water is becoming an increasingly important issue in many areas of the world especially. In remote and arid areas in Algeria. Among the non-conventional methods to desalinate brackish water or seawater, is solar distillation. The present study aims to improve the solar still performance, and to increase its yield. In this paper a new kind of technology, Nano particles(ZnO) different weight (10, 20, 30 and 40g) were added to the basin solar still and optimal depths water 1cm .to augmentation heat transfer and the productivity. The distillation performance experimentation has been conducted at the in Ouargla University, The conventional still yields 288 ml/m^{2}and the test still with added 40 g Zinc Oxide produces 325 ml/m² in a day. The still with Zinc Oxide (ZnO) has 13.02 % higher production compared with conventional still.**

Keywords—Solar still, Nanoparticle, brackish water, fresh water. solar distillation

I. Introduction

Fresh water is essential human requirement and without potable water, the life will be impossible. The availability of fresh water is one of the major defy facing humanity. Because the amount of the available freshwater is limited, and because of population increase and industrial development. The continuous lessening reserves of fossil fuels from day to other, and mounting, prices of petroleum products made inevitable for humans to think of solar energy that is vastly, plentiful and free. [1] Sellami et al 2016), solar energy as heat has many applications, such as saline or brackish water desalination. Unlike other distillation methods, solar stills use environmentally friendly solar energy to remove salts from saline brackish or saline water. Sellami et al. [2]. Solar desalination is a good way to support the needs of arid and remote areas by fresh water produced with clean and cheap manner.

Basin type solar still is a simple and easy to use, which can be used to obtain pure water with the use of solar energy, and can easily be built with locally available materials. Sellami et al.[3] solar stills were the first method which was used on a small scale to convert impure saline water to fresh potable water. In the year 1872 in Las Salines, Chile, Caros Wison, a Swedish engineer supplied fresh water to workers at a saltpeter and silver mine by the process of solar desalination. Gnanadason et al [4] was the first used term, Nano fluid Choi [5] in 1995 on the increase of thermal conductivity of fluids by adding nanoparticles. At the Argonne National Laboratory, USA.

The Nano fluids are fluids containing nanoparticles (normally less than 100 nm). Investigators have used certain types of nanoparticles such as Oxide metals, carbon nanotubes, metal carbides, carbon nanotubes, nitrides, metals nitrides, and nanotubes, functionalized nanoparticles to are colloidal suspensions of nanoparticles in a base fluid: water, ethylene/propylene glycol, oils and other lubricants.

Nanofluids has many special properties compared to its base liquid, such as high thermal conductivity and high solar intensity absorptivity , which will help to enhance the still productivity Guptaa et al. [6].

Lately, some investigators studied the influence of different types of nanofluids on the productivity of solar still. Elango et al. [7] enhanced the output of the still using nanofluids; stills with Aluminum Oxide (Al_2O_3), Tin Oxide (SnO_2) and Zinc Oxide (ZnO) nanofluids have 29.95 %, 18.63% and 12.67% increased productivity, respectively, compared with the witness still without nanofluids.

The present work shows study dealing with solar distillation for arid areas in Ouargla city south Algeria (latitude 31.95 north, longitude 5.40 east, and altitude 141 m above the sea level), these areas are blessed with huge underground water resources. The water has a salinity of 2–8 g/L, in most places and high solar radiation intensity, is some 3500 h per year, delivering around 2650 kWh/ (m^2•yr) of solar irradiance on the horizontal surface with Long duration of daily sunshine and High ambient temperature. Bechki et al [8] three solar stills were fabricated and the experiments at Ouargla University were conducted to compare the performance with Zinc Oxide (ZnO) nanoparticles and without nanoparticles in the same location and climate conditions simultaneously. Water Nano fluids of metals with different weight concentrations

II. Experimental setup

Three basin stills prototypes of simple single-slope solar distillers were built at the laboratory for the development of new and renewable energies in arid and Saharan areas (LENREZA) / Faculty of Mathematics and Subject Sciences / Kasdi Merbah University of Ouargla, ALGERIA Latitude: (31°57 North, Longitude: 5° 19 East) the experiment are carried out period from October 2018 .

Three-basin stills different weight (10, 20, 30 and 40g) and depth of optimal water 1cm Labiad et al.[9], with the same size were used to evaluate the solar desalination system performance. A photograph of a solar desalination setup are shown in Figs. 1.

Fig. 1. Photograph of a solar desalination setup

The distillers used in our experiments. They have the same dimensions. Each distiller consists of a wooden support as insulation for the distiller; it has a thickness of 0.04 m. A glass cover on the inner side of which, is carried out the condensation of water, it has the following dimensions (0.41 m × 0.75) m^2, its thickness is 0.003 m, and it is inclined with respect to the horizon of an angle of 30 °. A metal basin in which the evaporation takes place. It has the following dimensions: 0.05 m × 0,40 m × 0,60 m, it is made of galvanized steel with a thickness of 0,004 m - A channel for the recovery of distilled water which is at the level of the wooden cover and which is bound by a plastic tube to separately recover the distilled water outside the distiller.

The chosen insulation is polystyrene covering the absorbent to reduce heat loss, its thickness is 0.03 m; Pipes These are plastic pipes, with a diameter of 10 to 15 mm to bind the different parts of the distiller to transport brackish or distilled water; Graduated cylinders: These are graduated tubes used for measuring the volume of distilled water.

The amount of distilled water was measured at hourly intervals. The temperatures were measured using type K thermocouples. The wind speed was monitored using a NI Compact DAQ USB Chassis. The solar intensity was measured by a pyrometer with integrator (Kipp & zonen B.V., pyrometer model CMP 3).

Experiments are conducted at the University of applied science Ouargla, Algeria during the period from 9 am to 6 pm of October 2018 The air temperature, solar radiation, brackish water, and distilled water are measured every 1 h.

III. Results and discussion

As shown, Fig. 2 displays measured ambient temperature and solar irradiance versus local time for our experiment location. During our experiments, ambient temperature monitored was between 21,38 °C at 9:00 h and 38,19 °C at 14:00 h. Solar irradiance increases in the first half of the day and reaches its maximum value between 12:00 and 14:00, before it start to decrease in the afternoon. The maximum value recorded was 987 W/m^2 at 14:00 h local time.

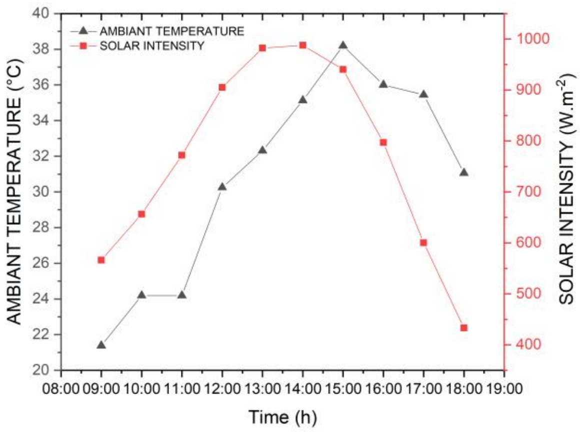

Fig. 2. ambient temperature and solar irradiance versus local time

Fig.3.presentation the hourly productivity for all experiments, versus local time. The curves trend indicates that the hourly yield is directly proportional to the solar radiation. The maximum values were recorded between 13:00h and 15:00h local time. The mean value of hourly production calculated at the end of experiment for each unit was 0.504 and 0.458 kg/m²/h for the units with Zinc Oxide (ZnO) and the conventional solar still respectively. The solar still with Zinc Oxide was shown as the best productivity it is due to the high thermal conductivity

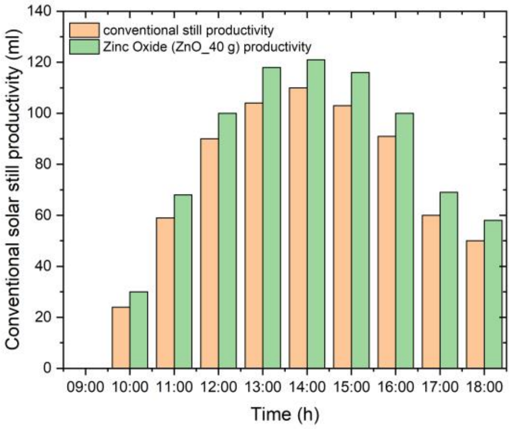

Fig. 3. hourly productivity versus local time

Fig. 4 displays various temperature (temperatures of the Basin, the temperature of the water in the basin, the temperature of the trapped steam inside the still and glass cover). Versus local time with 40g, weight of Nanoparticle. Almost all temperature curves in all of stills (conventional and test stills) follow the same trend as the solar irradiance. All of still temperatures reach their maximum values at 14:00 h.

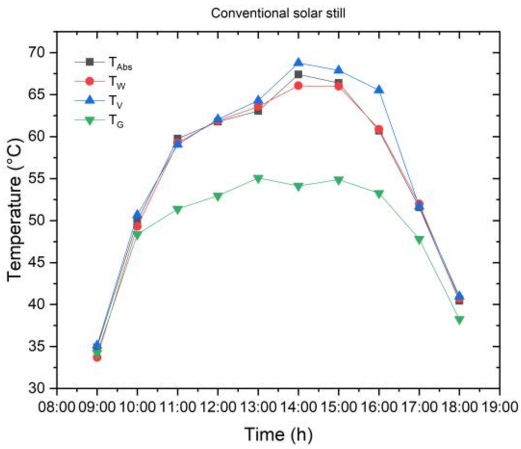

Fig. 4. a Various temperature versus local time

The highest temperature recorded for the still is that of the mixed vapor and air trapped inside the still (T vapor), because of the greenhouse effect and the overheating caused by the latent heat of vapor condensation. The maximum value recorded for this temperature was 68.1 °C. in the basin of, Zinc Oxide (ZnO). Temperatures of the Basin and temperature of the water in the basin are almost identical for all experiments, with negligible difference about 01 °C due to convective heat transfer between the base and the water brine, stirring water (forced diet). So we can write Tw ≈ T abs.

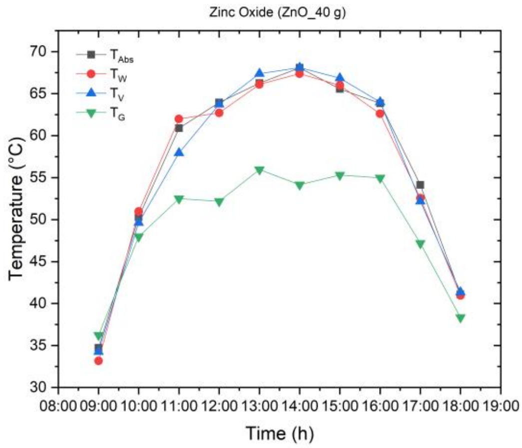

Fig.4 b. Various temperature versus local time with 40g, weight of Nanoparticle

Generally for all experiments, as we clearly observe the glass-cover (condenser) temperature (Tg) is lower than saline water in the basin (Tw), the difference between them reflects directly the amount of distilled water.

Fig. 5 shows the difference between temperatures water (Tw) and glass-cover temperatures (Tg) versus local time for all stills (conventional basin and test stills). This difference is directly proportional to the quantity of the distillated water . maximum value of temperature difference recorded between at 14:00h and 15:00h for all units with Zinc Oxide and the conventional still is 11,21, and 11,11 °C respectively

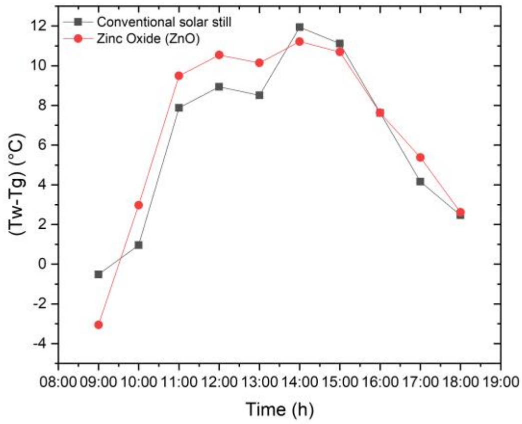

Fig. 5. the difference between temperatures water and glass-cover temperatures versus local time

At the Start of experiments, the gap for all stills is negative. (Tg > Tw); this was explained by the fact that at in the morning hours after sunrise, the glass-cover beginning to receive solar rays. before the basin brackish water which is still cold since it is still keeping night temperature because of thermal inertia; so, the glass-cover temperature become

slightly higher and therefore, the difference was shown negative.

IV. CONCLUSION

The major interesting results of the present work can be summarized in the following points:

• the increase in distillate production because of water temperature and evaporation rate is increased due to existence of Nano fluid , the cumulus for the all units is: , 3.25 and 2.88 kg/m2 Production for Zinc Oxide, with a weight optimal of 40g And the conventional still respectively. and productivity is increased by 13.02 % compared with the witness still

- The possibility of increasing the water productivity could be reached by lowering the water depths on the basin- absorbing plate.
- The accepted thermal performance of the constructed solar still with an increased evaporation rate and the faster condensation was achieved due to the appreciated contribution of the improved design parameters and the operational.
- The deciding contribution of using solar still a glass and role of cooling the glass cover was strongly observed on the increased temperature difference (Tw-Tg) as well as on the increased water productivity. Higher attention must be spent to the times of applying the cooling method.
- It was found that the geographical location may having a significant positive effect on the increased water productivity, especially for those locations with an abundant solar irradiation.

REFERENCES

[1]. Sellami, M.H., Guemari, S., Touahir, R., Loudiyi, K., 2016a. Solar distillation using a Blackened mixture of Portland cement and alluvial sand as a heat storage medium.Desalination. 394, 155-161.

[2]. 2 Sellami, M.H., Bouguettaia, H., Bechki, D., Zeroual, M., Kachi, S., Boughali, S.,Bouchekima, B. and Mahcene, H., 2013. Effect of absorber coating on the performance of a solar still in the region of Ouargla (Algeria). Desalination and Water Treatment. 21, 1-8.

[3]. Sellami, M.H., Belkis, T., Aliouar, M.L., Meddour, S.D., Bouguettaia, H. and Loudiyi, K., 2017. Improvement of solar still performance by covering absorber with blackened Layers of sponge. Groundwater for Sustainable Development. 5, 111-117

[4]. M. Koilraj Gnanadason, P. Senthil Kumar, G.Jemilda, S.Sherin Jasper Effect of Nanofluids in a Modified Vacuum Single Basin Solar Still International Journal of Scientific & Engineering Research Volume 3, Issue 1, January-2012 1 ISSN 2229-5518

[5]. Choi SUS. Enhancing thermal conductivity of fluids with nanoparticles Developments and applications of non-Newtonian flows. New York: ASME;1995. p. 99–105 [FED-Vol. 231/MD-Vol. 66].

[6]. Munish Guptaa,∗, Vinay Singha, Rajesh Kumara, Z. Saidb A review on thermophysical properties of nanofluids and heat transfer applications http://dx.doi.org/10.1016/j.rser.2017.02.073

[7]. T. Elango, A. Kannan, K.K. Murugavel, Performance study on single basin single slope Solar still with different water nanofluids, Desalination 360 (2015) 45–51.

[8]. D. Bechki , H. Bouguettaia , J. Blanco-Galvez , S. Babay , B. Bouchekima , S. Boughali , H. Mahcene Effect of partial intermittent shading on the performance of a simple basin solar still In south Algeria 10.1016/j.desal.2010.04.066

[9]. A. LABIAD, M. H. SELLAMI, R. CHERRAYE; Effect of different brackish water depths on the performance of a solar still. ISMRE 2018 Algerie

.