MINAR International Journal of Applied Sciences and Technology

Article type : Research Article

Date Received :11/07/2021
Date Accepted : 08/08/2021
Date published: 01/09/2021

: **www.minarjournal.com**

http://dx.doi.org/10.47832/2717-8234.3-3.2

THE PERFORMANCE OF A SINGLE SLOP SOLAR DISTILLER WHEN USING A TWO REFLECTOR

Yaseen. H. MAHMOOD[1] & Abeer Ibrahim ASHAWI[2]

Abstract

The lack of safe drinking water is a major problem in many areas. Most of which located within the range of high solar sun and the enormous potential of solar energy can be exploited to turn salt water into drinking water. The most economical and easy way to achieve this goal is to use solar distillation. Two low-cost "Single Slope" solar distillers were designed to examine the impact of adding concentrates and reflectors on daily yield and efficiency and then compare the results. Results obtained from practical experiments have shown that solar distillers with internal and external reflectors made of mirrors have increased in efficiency by 6% and 12% when one liter and two liters of river water are added, respectively, from the distiller under the effect of the parabola concentrator. The daily yield was also (60 and 240) ml higher for the solar distiller, which contained both internal and external reflectors.

Keywords: Solar Thermal, Desalination, Solar Distillation , Concentrator, Efficiency of Solar Distill.

[1] Tikrit University, Iraq, d.yaseen.ph.sc@tu.edu.iq, https://orcid.org/0000-0001-6883-6654
[2] Tikrit University, Iraq, aljoboryabeer@gmail.com, https://orcid.org/0000-0003-3776-6715

Introduction:

The lack of safe drinking water for humans, animals and plants in many regions of the world. Because of the lack of energy. Researchers have worked to obtain alternative and cheap sources of water. Solar energy was therefore a viable and cheap alternative to disposing of salts in water. Several studies have also been conducted for solar desalination [1,2]. The effect of the internal reflector on the productivity of the single slop solar distillation during summer and winter was studied both experimentally and theoretically. They introduced a mathematical model that took into account the effect of all walls of the distiller on the amount of solar radiation received into the saline solution, and the model was validated with experimental data. They concluded that the simultaneous use of IR on the front and sidewalls boosts the efficiency of the device by 18%. However, the IR installation on the rear wall can increase annual efficiency by 22% [3]. Cooling the glass cover in different ways, to improve the performance of solar trailers. They found that cooling glassware achieve a reduction in the temperature of the glass cover in the range of 6-20° C .While improving the efficiency and productivity of the solar stilled to a maximum of 15.5% and 20%, respectively. They concluded that for the pipe solar distiller with cooling airflow for glass cover, daily productivity improved by about 32.8%, and improved by almost 59% as cooling water flowed more than the distillation without cooling [4].An experimental study on the solar distiller to see the effect of adding modifications such as a photovoltaic heater on solar distillation device. The design of the solar stilled with dc heater enhance the productivity of the distiller by up to 1098% [5]. Solar distilled can be divided into two types, with the addition of an external reflector and a second with an internal reflector, or both. In addition, I split the external reflectors, too. He concluded that the installation of reflectors in places with low solar radiation, or low ocean temperature, was more effective. [6]. A rotating solar distiller with an external reflector was fixed southward and the reflector was moved at regular angles to maintain solar radiation continuously on the distiller basin. In practice, the distiller's yield in case the reflector is fixed once and moved again. Increased yield was also observed in the case of solar distiller movement [7]. Solar distiller with solar concentration by autonomous device (Radiation center). Solar distiller design. It was used to transport oil to raise the temperature of the water inside the basin. A mathematical model was designed to simulate the system from 10:00 to 16:00 for the city of Kirkuk. The study was used to analyses system performance [8]. Improved desalination system using black steel wool fibers as porous material in the solar basin. They concluded that pre-heating of 40%, 50% and 60% of saltwater increases the freshwater productivity of the solar desalination system (the traditional solar distillation integrated with solar panels) by 10.4%, 15.5%, 20.9%, and energy efficiency by 8.2%, 13%, and 20%, respectively. The use of black steel wool fibers increases the production of the distiller [9]. Using nanoparticles that would change the Wettability of the condensation surface. I use materials that have a moisturizer. Like titanium oxide and silicon nanoparticles. Empirical results indicated that condensation surfaces covered by nonmaterial's improved properties and increased the efficiency of the solar distiller. 20% glass condensation cover [10].Design and manufacture of a simple solar distiller for distilling household drinking water. His performance was also tested, using Amman seawater. Water has also been tested for chemical and biological activity. The results showed that the samples contained different metals and no bacterial activity was detected in the samples after solar distillation [11].Field work to design and test a solar distillery to produce drink-friendly water using single-slope solar dish with solar dish. The results have been compared to other solar designs. To examine the performance and effectiveness of the distiller for application in Iraq, Najaf during the Winter Session (Nov., Dec., Jan.) 2018-2019. Evaluation is based on the effects of operating parameters [12] .In the current search, two one-slop solar distillers were used. The impact of adding an internal and an external reflector, as well as adding both reflectors and comparing performance in terms of returns and efficiency, was examined. The use of reflectors has been shown to have a significant impact on their daily production, increasing the efficiency of the system.

Theoretical part:

The "rate of heat transfer by convection (q_{cw})" from the water surface to the glass condensation cover is given by the following relation:

$$q_{cw} = h_{cw}(T_w - T_g) \quad \text{.....(1)}$$

where: h_{cw} convective heat transfer coefficient from water to condensing cover , T_w temperature of water , T_g temperature of glass.

From the surface of the water to the surface of the glass cover is given by the equation:

$$q_{ew} = h_{ew}(T_w - T_g) \quad \text{.....(2)}$$

Where (q_{ew}) is "the rate of evaporative heat transfer , h_{ew} is the evaporative heat transfer coefficient [13].

The rate of heat transport by radiation can also be given by the following equation:

$$q_{rw} = h_{rw}(T_w - T_g) \quad \text{..... (3)}$$

Where q_{rw} is the rate of radiative heat transfer, the (hrw) is the radiative heat transfer coefficient from water surface to the glass cover "

Where L is the latent evaporation temperature of less than 70 ° C and is given by formula [14]:

$$L = 2.4935 \times 10^6 [1 - 9.4779 \times 10^{-4} T + 1.3132 \times 10^{-7} T^2 - 4.7947 \times 10^{-9} T^3]$$

.....(4)

The clockwise distillation output per square meter of the solar distiller can be obtained by the equation:

$$m_{ew} = \frac{h_{ew}(T_w - T_g)}{L} \; 3600 \text{ kg / m2 /h} \quad \text{..... (5)}$$

The efficiency (η_i) of solar distiller [15].

$$\eta_i = \frac{m_{ew}.L}{I(t)} = \frac{\{h_{ew}.(T_w - T_{cl})\}}{I(t)} \quad \text{..... (6)}$$

Where $I(t)$: solar radiation at time.

Experimental part

The single slope solar still was fabricated from low-cost local materials .Plywood was used to manufacture the outer structure (still box) with a base length (80 cm), width (75 cm), thickness (2 cm) and the height of the still from the back (65 cm). The still box painted from the inside by a charcoal black to ensure the highest absorption of the falling solar radiation. Silicon was used to connect the wooden pieces. For the purpose of increasing the insulation. The usual glass was used with a length of (95 cm), width (72 cm) and thickness (4 mm) to allow greater passage. A measure of radiation at an angle (45 degrees) to facilitate the descent of condensed water droplets as shown in Figure (1).

Figure (1).Single slope solar still.

Galvanized iron was used to manufacture the inner basin in which the salt water is placed with dimensions (50 x 50) cm, height (5 cm) and also painted it in charcoal black as shown in Figure (2).

Figure (2) .Metal basin.

Internal and external reflectors from the regular mirrors were used to improve the performance of the solar still, where the external dimensions were (36 × 62) cm, while the internal ones were placed in the sides and the back wall, the dimensions of each of them were (18 × 22) cm, as shown in Figure (3).

Figure (3) .Solar still with internal and external reflector of mirrors.

The parabolic dish reflector was also used to increase the productivity and efficiency of the solar still, as the dish had a diameter of 120 cm, and mirrors with dimensions (3 x 3) cm were attached to it and placed on a mobile base to facilitate its movement to track the sun as shown in Figure (4).

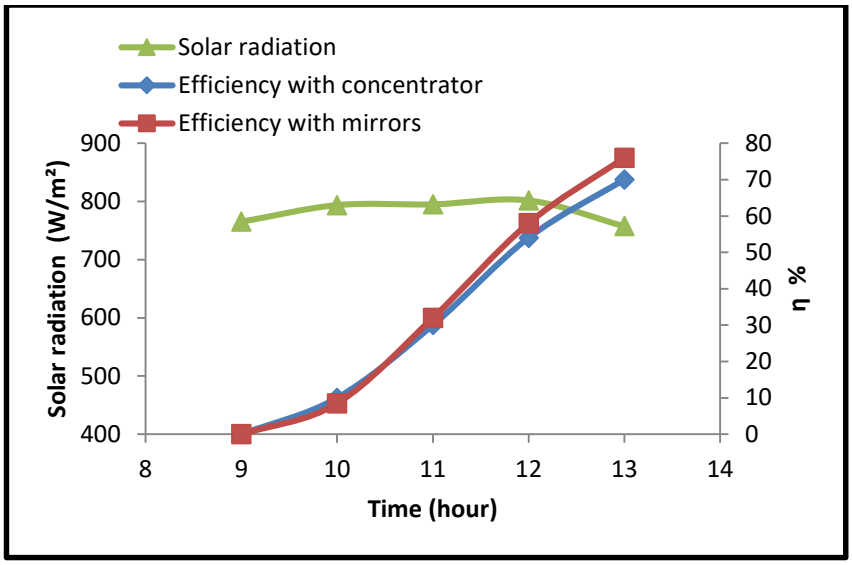
Figure (4). Parabolic plate reflector and solar stilled.

Results and discussion:

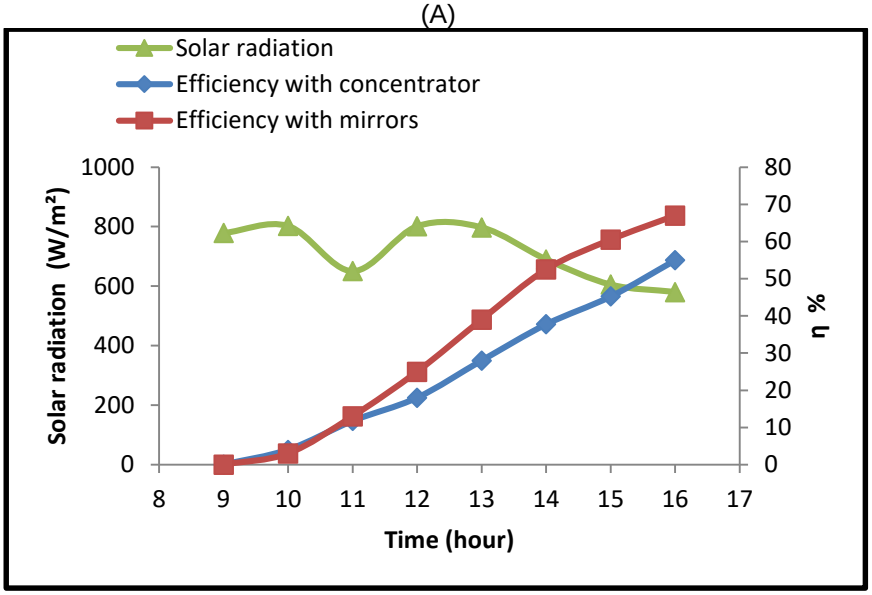
Several experiments were conducted of a solar distiller. The system fix in Shirqat, Salah al-Din, at longitude (43.242) and latitude (35.492), and the effect of adding a parabola, and flat reflected internal and external. In addition, performance of the solar still when adding one and two liters of river water was studied.

1- The efficiency of the solar still in the case of adding internal and external reflectors of the mirrors and in the case of a parabolic dish reflector:

As we can see in the obtained result of the procedure that has been done in April it found that when adding one liter of water river on two on two distiller which one of them .Contain an inner reflector. while the other is under the effect of parabola concentrator .From the comparison between the result of these two distillers it found that the efficiency of the 1st distiller increasing 6% than the 2nd ,while when adding 2 liter the efficiency of the first distiller increasing 12% than the 2ND , as shown in fig (5)A,B .The inner reflector, reflect the radiation that falls on the inner walls of the distiller .While the outer reflector concentrate the solar radiation that enters the distiller. Therefore, the condensation and evaporation increase. While the parabola reflected, concentrate the solar ray on water, which leads to arise in temperature. However, in same time, it increases the glass temperature, which gives a negative result on the efficiency, and this is consistent with [18-19].



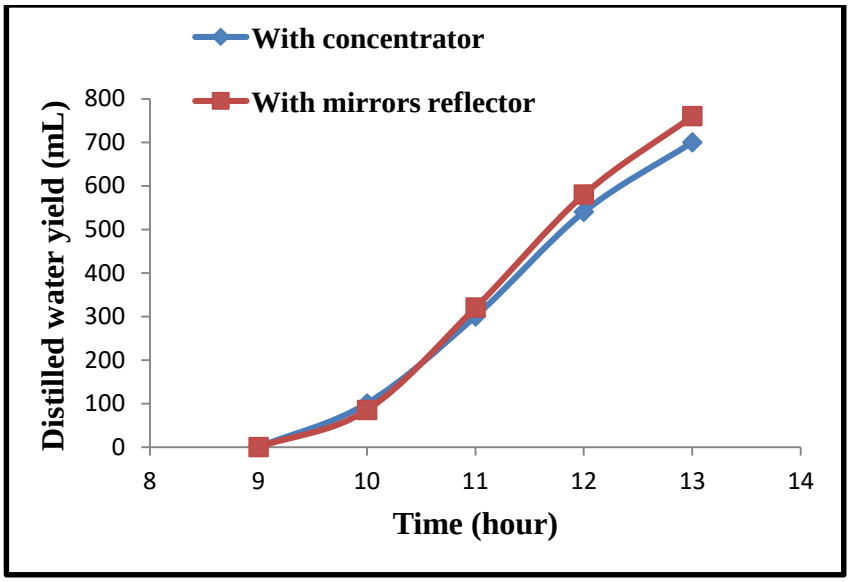
(A)



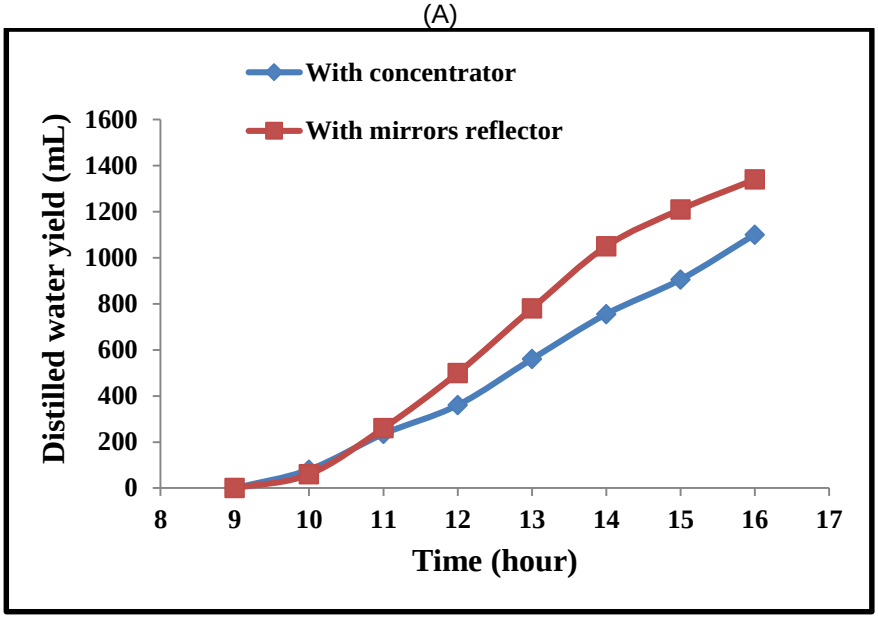
(B)

Figure (5). The relationship between efficiency and time with the presence of a parabola concentrator and an internal and external reflector of mirrors (A) when adding one liter (B) when adding 2 liters.

The effect of adding a parabola. With inner and outer reflectors. In addition, on the daily yield for two solar distiller. Figure (6) A,B show the relation between time for two different day in April. When adding one liter and two liter of river water. Than it had been measured every hour from 9 A.m. until 4 P.m . Then comparing the results from the first distiller that contains inner and outer reflector and the other distiller .That was under the effect of the first distiller. The effect of the parabola, it shows that the production of the first distiller increased about 60 ml than the other. When adding 1 liter as shown in figure (6).While the production increased 240 ml when adding 2 liters shown in figure (6) .The center of the parabola concentrator heats the distillers glass which leads to less condensation for vapor.Therefore the production decreases less than the distiller that contain inner and outer reflector that works on concentrating the solar rays that fall on the back wall and side of solar distillersand this is consistent with the researchers [18-19].



(A)



(B)

Figure (6) The relationship between the daily yield and time when adding a parabola concentrator and adding an internal and external reflector(A) when adding one liter (B) when adding two liters.

Conclusions:

The results obtained from practical experiments proved that the efficiency and productivity of the solar still increases with the increase for radiation falling on the still and that the maximum efficiency is between twelve noon and two o'clock in the afternoon in all experiments. The charcoal black color of the basin and the inner walls of the solar still has a positive effect on the performance of the solar still. The use of a parabola concentrator and internal and external reflectors significantly increased the efficiency and daily yield.

Reference:

Mahmood Y.H, Rajab AA. Fabrication and study of a single Basin Double-slope solar distilled. Tikrit Journal of Pure Science. 2020;25(6):69-74.

Mahmood Y.H, Ashawi AI. Experimental estimation of the performance of the homemade single slop Solar distilled. Tikrit Journal of Pure Science. 2021;26(2):98-102.

KarimiEstahbanati M, Ahsan A, Feilizadeh M, Jafarpur K, Ashrafmansouri S-S, Feilizadeh M. Theoretical and experimental investigation on internal reflectors in a single-slope solar still. Applied Energy. 2016;165:537-4.

Omara Z, Kabeel A, Abdullah A. A review of solar still performance with reflectors. Renewable and Sustainable Energy Reviews. 2017;68:638-49.
Abdallah S. Productivity Enhancement of Solar Still with PV Powered Heating Coil and Chamber Step-Wise Basin. Journal of Ecological Engineering. 2018;19(2):8-15.
Muftah A, Sopian K, Alghoul M. Performance of basin type stepped solar still enhanced with superior design concepts. Desalination. 2018;435:198-09.
Tabrizi HB, , Nia MF. Performance of Rotating Solar Still with Rotating External Reflectors. International Journal of Engineering. 2019;32(6):884-92.
Aldoori WH, Ahmed AH, Ahmed AM. Performance investigation of a solar water distiller integrated with a parabolic collector using fuzzy technique. Heat Transfer-Asian Research. 2019;49(1):120-34.
Elbar ARA, Hassan H. Enhancement of hybrid solar desalination system composed of solar panel and solar still by using porous material and saline water preheating. Solar Energy. 2020;204:382-94.
Zanganeh P, Goharrizi AS, Ayatollahi S, Feilizadeh M, Dashti H. Efficiency improvement of solar stills through wettability alteration of the condensation surface: An experimental study. Applied Energy. 2020;268:114923.
Wazwaz A, Khan M. Seawater desalination using an innovative solar distiller. desalination and water treatment. 2020;173:117-22
Al_qasabmr, abed qa, abd al-wahidwa. enhancement the solar distiller water by using parabolic dish collector with single slope solar still. Journal of Thermal Engineering. 2021;:1000-15.
Patel RVP, Kumar A. Experimental Investigation of Double Slope Solar Still for the Climatic Condition of Sultanpur. International Journal of Engineering and Technology. 2017;9(6):4019-33.
Munaf AA, Patrick S, , Kumar MS. Experimental investigation and performance of Double slope single basin solar still. Journal of Xidian University. 2020;14(4):2837-43.
Badran O. Theoretical Analysis of Solar Distillation Using Active Solar Still. International Journal of Thermal and Environmental Engineering. 2010;3(2):113-20.
Hassan H, Ahmed MS, Fathy M, Yousef MS. Impact of salty water medium and condenser on the performance of single acting solar still incorporated with parabolic trough collector. Desalination. 2020;480:114324.
KarimiEstahbanati M, Ahsan A, Feilizadeh M, Jafarpur K, Ashrafmansouri S-S, Feilizadeh M. Theoretical and experimental investigation on internal reflectors in a single-slope solar still. Applied Energy. 2016;165:537-4.
Kabeel A, Omara Z, Essa F. Enhancement of modified solar still integrated with external condenser using nanofluids: An experimental approach. Energy Conversion and Management. 2014;78:493-8.
Abdullah A, Omara Z, Essa F, Alarjani A, Mansir IB, Amro M. Enhancing the solar still performance using reflectors and sliding-wick belt. Solar Energy. 2021;214:268-79.