International Journal of Engineering

Journal Homepage: www.ije.ir

RESEARCH NOTE

Performance of Rotating Solar Still with Rotating External Reflectors

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PAPER INFO

Paper history:
Received 02 February 2019
Received in revised form 10 April 2019
Accepted 02 May 2019

Keywords:
Solar Still
External Reflectors
Solar Energy
Angle Shifting
Desalination

ABSTRACT

In this research, a rotating solar still that uses external bottom reflectors was experimentally investigated. The solar still and reflectors have the capability to shift their angle with respect to the south and the reflectors have the capability to shift their angle with respect to the horizon. The experiment has been performed in both fixed and rotating states. For the fixed state the solar still was placed toward south and the reflectors were set in such a way to reflect sun rays on the bottom surface of the basin at solar noon. For rotating state, the solar still and reflectors were set manually every half an hour in such a way to reflect sun rays on the bottom surface of the basin and the system was directed toward the sun all the time. The experiments were performed from November to December for 27 days. Sunny days results indicated that on average, distilled water gained using rotating mode was about 64% more than the fixed mode. Both the rotating and fixed mode yield for two cloudy days with respect to the average yield of sunny days decreased by 47 and 53%, respectively.

***doi**: 10.5829/ije.2019.32.06c.13*

1. INTRODUCTION

Solar energy is one of the renewable energy sources necessary to be utilized for the socioeconomic development of a nation. Solar thermal energy has been harnessed to generate electricity, dry crops, heat buildings, destroy hazardous contaminants, desalinate sea water, etc., and manufacture advanced products/materials and help the environment by reducing harmful gases from fossil fuel combustion [1]. Solar distillation is one of the most prominent solution for production of safe drinking water [2]. Human needs clean water for residential, agricultural, and industrial consumption; however, a small percentage of the earth water resources is fresh water. This little amount of water is not also equal everywhere and a high percentage of it exists in the poles in icy form. Pure and fresh water is being scarce day by day [3]. Therefore, it is very important to manage water consumption. It has more importance in some regions, which have water deficit and drought. Therefore, investigating and improving systems such as solar still is very important and valuable. A common failure of the solar stills is that the amount of gained pure water is very low. One of the ways for increasing this amount is to use internal and external reflectors. A conventional solar still plant was invented by Charles Wilson, a Swedish engineer in 1872, as commercial plant [4]. This solar still was a basin type with a total area of 4450 m^2, which could distill 22.7 m^3 water in a day. This solar still worked for 40 years. Reflectors were designed to increase the fresh water productivity of solar still at early of 20 century. Maria Telkes from the Massachusetts Institute of Technology made a portable solar still to be used in life boats. A clear plastic and a felt layer, which could absorb seawater, had made this solar still. Office of saline water started in Florida, USA, which has done extensive research about types of solar still such as basin solar still and multi-effects ones [5].

Many research have been conducted on the function of solar still. Some investigated the function of solar still by changing the application of reflectors. Tanaka, et al. [6] analyzed a tilted-wick solar still with an external flat reflector on a winter day. The Daily amount of the gained distilled water by solar still with a tilted reflector, when the length of the reflector was half of or

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equal to the length of the solar still, was 15 and 27% more than a solar still with a vertical reflector, respectively. Moreover, another study by Tanaka and Nakatake [7], analyzed a tilted-wick solar still with a vertical external reflector. It included numerical analyzing of mass and thermal transfer in the solar still in order to calculate distilled water for 4 days in 4 seasons of the year. It was assumed that the solar still could turn towards south once a day. Theoretically, they calculated the best angle of solar still than the horizon, and then the south. The average of increasing daily amount of distillate of the tilted-wick solar still for these 4 days with vertical reflector, once a day turning of solar still and tilted than the horizon suitable for any season, was 41%. Further, they investigated the function of a basin solar still with external and internal reflectors in Japan in a winter time. Predicting productivity, with practical productivity particularly in some days with a clean air was approximately equal and there was a little different about 6%. It showed that one could estimate the reflected radiation from reflectors with proper precision. The study showed that daily productivity will be increased from 70 to 100% by optimizing a basin solar still using reflectors [8].

Khalifa and Ibrahim [9] studied a practical work with a basin solar still consisted of external and internal reflectors in the winter. The external reflector and glass cover of the solar still can shift their angles. Their work presented that daily productivity will be increased with a bigger cover angle ignoring the reflector angle. Shifting the cover angle in the solar still without any reflector does not change the efficiency. If the external reflector is vertical in the winter and the cover angle becomes more than 40˚, the reflector efficiency will be decreased. The best suitation in the winter is the cover angle 20˚ and the reflector angle 20˚, which its efficiency is 2.45 times of a solar still without any reflector.

Moreover, Tanaka worked on a theoretical analyzing on the basin solar still with external and internal reflectors. The length of the external reflector was half the length of the solar still and the latitude was 30˚. Different daily amounts of distillate regarding the shift in both angles of solar still cover and external reflector were reported. The monthly-optimized angle of external reflector for the cover angle of 10˚ to 50˚ was also obtained. The average daily amount of distillate increasing during a year for a solar still with an optimized angle of the external reflector as well as the internal reflector, with cover angles 10˚, 30˚ and 50˚ compared to non-reflector ones were 29, 43, and 67%, respectively [10].

Further, Tanaka did a theoretical analyzing on a basin solar still with external and internal reflector. The length of external reflector was equal to the length of solar still and the latitude was considered 30˚. Geometric model to estimate the radiation of external reflector and performed and numeric analyzing on mass and thermal transferring in solar still were obtained. This research has been done for 3 days in the spring, summer, and winter, and with a fixed cover angle 20˚ and a proper angle for reflector, which is suitable for each season for a solar still with a reflector, the daily productivity was 41, 25, and 62% more than a conventional basin type still, respectively [11].

Huang and Chang [12] calculated the best angle of the external reflector than the vertical state for a basin solar still using the Levenberg-Marquardt method. Their study showed that in a winter day, productivity will increase about 27.8% compared to when the reflector is vertical, by adjusting external reflector angle and keep it stable; it is 2.38 times more than the solar still without any reflector .

Some researches looked to the function of solar still by shifting in using the reflectors and other factors for increasing productivity.

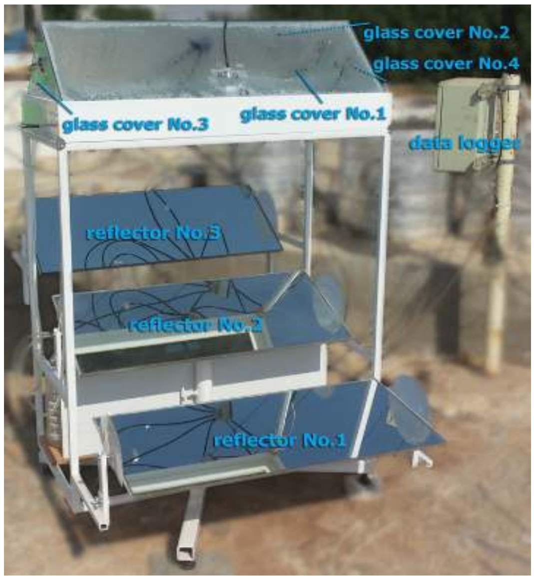
Tanaka [13] used a vertical multiple-effect solar still, which had vertical and parallel parts in contact with a cloth impregnated with saline water and a flat reflector. Its maximum daily productivity was reported 13.3 kg/m²day when the horizontal radiation was 13.4 MJ/m²day until 15.7 MJ/m²day, and on the glass cover, was 20.2 MJ/m²day until 22.9 MJ/m²day. This productivity is 5.5 times more than a basin solar still and other similar multiple-effect solar stills.

Study conducted by Omara et al. [14] compared two kinds of solar stills: a basin solar still and a stepped solar still with external and internal reflectors, and both of them were applied in a similar climate. The productivity of the stepped solar still with reflectors was increased about 125% more than a basin solar still .

Segura et al. [15] suggested the properties of any kinds of reflectors. Tests were done on these reflectors in a simulated indoor and outdoor place so that they can gain the reflectors' lifetime and properties like destruction process, its appearance, and optical properties. Three main examined reflectors were glass, aluminum, and compound with silver. A glass reflector has more lifetimes.

Omara et al. [16] compared two kinds of solar stills: a conventional solar still and a corrugated solar still with double layer wick material and internal reflector. The productivity of the optimized solar still was increased about 145.5% than a conventional solar still. Further, Omara et al. [17] presented a review of solar stills with reflectors and in their article; they classified the solar stills with reflectors. Solar stills can have an internal reflector, an external reflector, or both of them. The external reflectors were also divided into two groups: upper reflector and lower reflector. They concluded that installing the reflectors in places, which have weak solar radiation or low ambient temperature is more effective. For more output, the reflector angle must be appropriate to the season. Muftah et al. [18] investigated the productivity rise of a stepped solar still using external and internal reflectors, absorber materials (fins) and external condensers. The productivity of solar still had a rising about 29% from 6.9 kg/m² to 8.9 kg/m².

Various studies have been preformed on increasing the output of solar stills; some of these studies can be found in literature [19]. However, there is no research about the effect of frequent adjusting the solar stills and reflectors so that the solar radiation reflects on the basin area of the solar still. In addition, the arrangement of the external reflectors and the situation of these reflectors to each other and their turning are not similar to other common reflectors were reported. Therefore, this study will study and compare the rotating state of solar still and reflectors in every half an hour manually with a mode that the solar still and reflectors are stable during the day.



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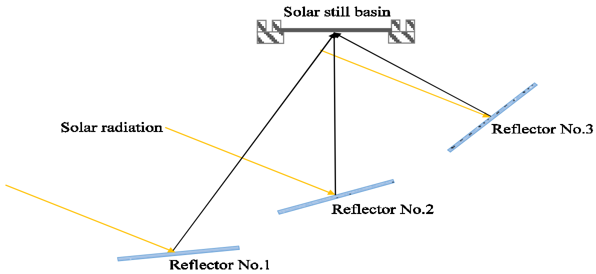


(b)

Figure 1. Solar still view at the test site (a) Reflector numbering with reflecting criteria (b)

2. EXPERIMENTAL APPARATUS

Solar still used in this experiment is a basin solar still with three external reflectors, which the reflectors are under the solar still and shown in Figure 1 with numbering the glass covers and reflectors. All the system can rotate and shift its angle with respect to the south. Each external reflector can also rotate around an axis, which crosses from the center of each reflector and shifts its angle with respect to the horizon. The three used reflectors are made from mirror with 800 mm long and 350 mm wide.

A part of the solar still, which is under the basin, is made of glass so that the reflected light can cross it and reaches to the lower surface of the basin. The distance of this glass area to the lower surface of the basin is 15 mm and has 775 mm long and 330 mm wide. Basin is 800 mm long and 347 mm wide; the used plate thickness is 0.6 mm and made of iron-galvanized plate and the lower and upper surface has been painted black.

3. EXPERIMENTAL METHOD

Experiments were performed for 27 days from 7 November until 12 December that 19 days was clear and sunny and the rest was semi-cloudy, cloudy, and dusty in campus of Jundi-Shapur University of Technology, Dezful, Iran at the longitude of 48.36° and latitude of 32.42°. Water thickness in the basin was kept 15 mm. Input water temperature was equal to the environment temperature. The amount of produced distilled water by the solar still was measured with an accuracy of 1 ml. The chemical features of the input water to the solar still and output water from the unit were shown in Table 1. The amounts of solar radiation perpendicular to the cover glass areas, the lower glass area under the basin, and three reflectors were measured using the device TES-132 with an accuracy of 0.1 W/m^2 for less than 200 W/m^2 and 1 W/m^2 for more than 200 W/m^2. Temperature sensors of type K with an accuracy of 0.1℃ were used for measuring the basin water temperature. The sensors have been connected to a data logger with accuracy 0.015℃ and total uncertainty of measuring temperature obtained 0.066℃ [20]. The experiment was performed one day for rotating state and the next day for the fixed state.

TABLE 1. Chemical features of water

	PH	Electrical conductivity (μs)	K^+ (ppm)	Na^+ (ppm)	Calcium carbonate (mg/l)
Input water	8.2	29000	68	410	300
Output water	7.2	39	0	3	40

3. 1. Rotating State Tests were operated from 8 a.m. to 5 p.m. The system includes a solar still and reflectors, adjusted manually in every 30 minutes so that it faces towards the sun. This means that the image of normal vector of the reflectors on the horizontal plane does not have any angular divergence to solar azimuth angle. The reflectors angles to the horizon are adjusted manually. The angle was calculated according to the solar altitude angle in order to reflect the sunlight on the lower surface of the basin. Solar altitude angle (α_s) and solar azimuth angle (γ_s) can be obtained using the available equations [21].

3. 2. Fixed State The tests were performed for the fixed state of solar still from 8 a.m. to 5 p.m. Since the solar azimuth angle at solar noon is 0˚, the solar still and reflectors faces south during the test and the reflectors were also adjusted so that they can reflect the light on the lower area of the basin at solar noon.

4. RESULTS AND DISCUSSIONS

In the solar still, the heat flux from the sun enters from the glass cover to the basin. The basin will absorb the heat, which raises the water temperature, and eventually, the water will start to evaporate. The evapored water will be distilled when encountering the interior surface of the glass cover and will exit through the water trough in the solar still. The amount of water temperature in the solar still, the productivity of solar still, pure gained water from the solar still, depends on various factors, e.g. solar radiation flux, water thickness in solar still basin, and the input water temperature etc. Table 2 shows the testing date for 19 sunny days, daily productivity of both states in these days and the average of solar radiation heat flux, perpendicular to the lower glass surface under the basin.

Results indicate that the average of rotating state productivity compare to the average of fixed state productivity shows an increase of 64%. The most productivity in the rotating state was observed in day 14th of November with an amount of 8.31 kg/m^{2}day and for the fixed state on 13 November and the amount of 5.612 kg/m^{2}day. The high productivity was due to the higher solar radiation comparing to other days. Therefore, the days 13 and 14 of November were selected as basis for comparison and discussions.

4. 1. Effect of Solar Radiation Flux Figure 2 illustrates the basin water temperature and the environment temperature (a) for rotating state on 14 Nov. and (b) for the fixed state on Nov. 13. It can be noticed from comparing two states that the average of basin water temperature in rotating state and during the day is higher, the average was 62.8ºC and 52.2°C for the rotating and fixed states, respectively. In addition, one can see that the water in the solar still basin obtained a high temperature faster and keeps its temperature for a longer time in the rotating state. Hence, it can be maximized in the rotating state after 4 hours and 30 minutes, although this time for a fixed state is 5 hours. Moreover, it is shown that the maximum water temperature in the rotating state is 79.2℃ and in the fixed state is 76.2℃.

Figure 3(a) shows the solar radiation flux perpendicular to the four glass area covers for rotating state on 14 Nov. versus time. As it was expected, the

TABLE 2. Daily yield of rotating and fixed states in sunny days

Rotating state			Fixed state		
Date	Daily yield (kg/m^2 day)	Average of solar radiation perpendicular to the lower glass area (W/m^2)	Date	Daily yield (kg/m^2 day)	Average of solar radiation perpendicular to the lower glass area (W/m^2)
8/11	6.505	714.5	7/11	4.056	391.4
12/11	7.539	941.7	13/11	5.612	591.1
14/11	8.310	1087	15/11	4.809	398.1
16/11	6.635	877.5	17/11	3.969	416.9
28/11	6.956	995.4	25/11	4.502	580.5
2/12	7.067	1023.3	1/12	4.409	452.5
4/12	7.157	1069.3	3/12	4.441	472
10/12	7.291	1115.4	5/12	3.501	415.5
12/12	6.606	1091.7	9/12	4.157	481.8
			11/12	3.926	469.8
Average yield: 7.118 kg/m^{2}day			Average yield: 4.338 kg/m^{2}day		
The Rise of the average of rotating state yield to the average of fixed state yield: 64.08%					

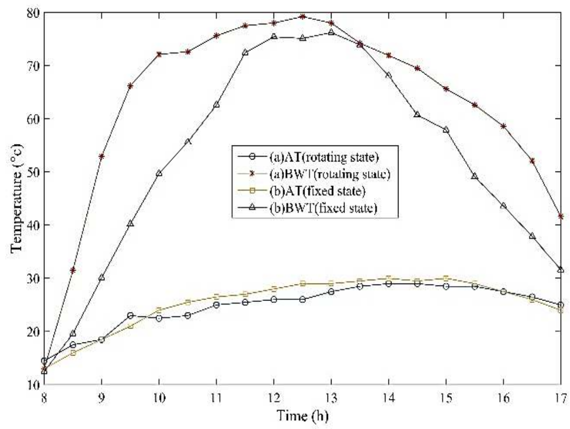
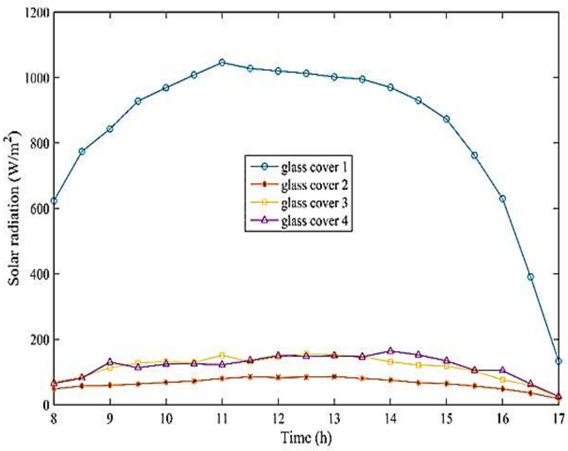


Figure 2. Basin water temperature (BWT) and ambient temperature (AT) vs. time for (a) the rotating state on 14 Nov. and (b) the fixed state on 13 Nov.

solar radiation perpendicular to the glass cover area, which faces to the sun, is more than all the others and is less for the glass cover that is back to sun than the rest of glass covers. The solar radiation perpendicular to the area of No. 3 and 4 glass covers (triangle covers) is approximately equal and their minor difference is due to solar radiation reflected from the environmental factors.

Figure 3(b) shows the solar radiation flux perpendicular to the reflector areas and the glass area under the basin versus the time on 14 Nov. for rotating state. Solar radiation perpendicular to the No. 1, 2, and 3 reflector areas increased, respectively. Because the angle between the normal vector of reflector area and solar radiation to the horizon for No. 1, 2, and 3 decreased, respectively. Note that when the solar radiation angle to the horizon was increased, the solar still chamber shaded on the No. 3 reflector and covered some part or its entire surface and the amounts of measured solar radiation related to this reflector have been measured from the section of the surface, which obtains the solar radiation. That is why one can see that the solar radiation perpendicular to the lower glass area increases at the beginning and at the end of the day that the solar radiation angle to the horizon becomes small and will be decreased by shading on No.3 reflector.

Figure 4(a) shows the solar radiation perpendicular to the four cover glass area for the fixed state on 13 Nov. versus time. The solar radiation perpendicular to the area of No. 3 and 4 glass covers are symmetry to each other. One can notice for No. 4 glass cover, which the solar still is perpendicular to it, increases at the beginning of the day. The angle difference between the normal vector of the glass area and the solar radiation will be larger and has more effect on gaining the solar radiation amount perpendicular to the glass area.



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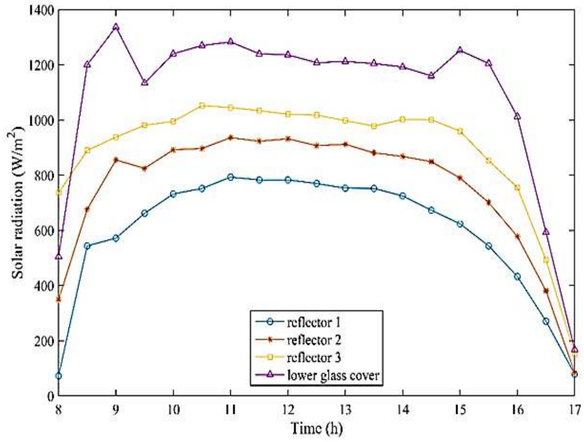
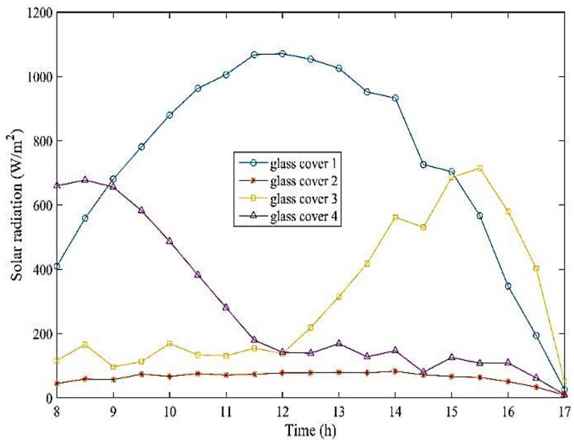


(b)

Figure 3. Rotating state, solar radiation perpendicular to the four glass area covers (a) and to the reflector areas and the glass area under the basin (b) vs. time on14 Nov.



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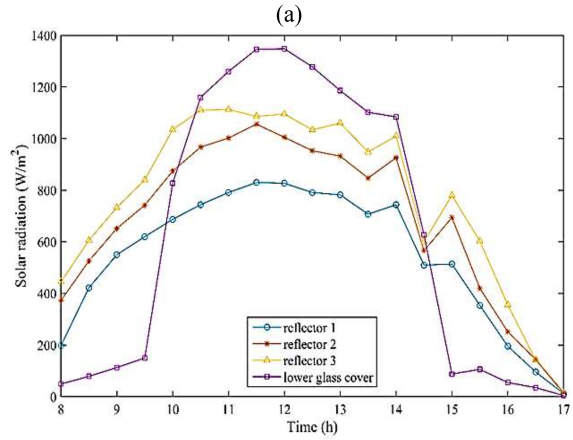


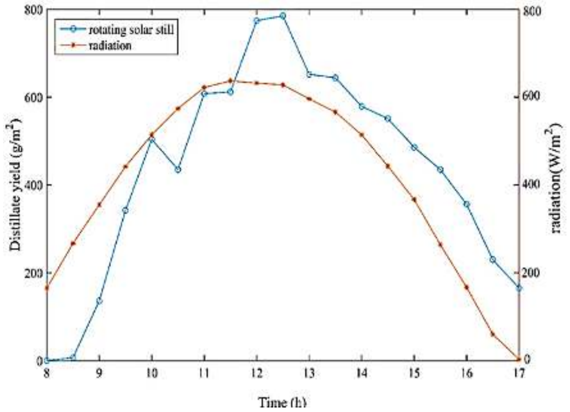
(b)

Figure 4. Solar radiation perpendicular to the four cover glass area (a) and to reflectors areas and lower glass area of the basin (b) vs. time for the fixed state on 13 Nov.

The same approach can be used for No. 3 glass cover at the end of the day because the solar noon is the same as the local 12 p.m., in this day, the test had started four hours before the solar noon and has ended five hours after it. It can be seen that the average solar radiation perpendicular to the area of No. 1 glass cover (which faces the sun in rotating state and faces south in fixed state), is 838.7 W/m^2 in rotating state and 734.1 W/m^2 in the fixed state. Figure 4(b) shows the solar radiation perpendicular to reflectors areas and lower glass area of the basin on 13 Nov. for the fixed state versus time. It is understood that vertical solar radiation on the lower glass area under the basin suddenly increases or decreases. Although the reflectors were adjusted, which can reflect the light on the lower glass area of the basin at solar noon, there is a geometry relationship between the solar radiation angles to the south and reflecting from the reflectors that cause the reflectors, also keep their effects for a longer time before and after the solar noon. Radiation on the lower glass area of the basin is the main aspect of testing the rotating state and the average of vertical solar radiation on the lower glass area of the basin is 1087 and 626 W/m^2 for rotating and fixed state, respectively.

4. 2. Hour Productivity Figure 5 depicts the productivity (amount of pure water from the solar still exit) and solar radiation on a horizontal surface versus time for rotating state on 14 Nov. and for the fixed state on 13 Nov. The productivity is zero for both states at the beginning of the day. Hence, the basin water temperature needs time and the maximum productivity obtained half an hour after the solar noon. If the productivity increases suddenly at some times of a day (usually this happened for the rotating state), the productivity of the next 30 minutes decreases due to the entry of the input water which has a temperature equal to the ambient temperature, so the distilled water can be compensated. As it is shown in Figure 5, the productivity of rotating state at 10:30 a.m. has been decreased. Comparing both the rotating and fixed state, one can notice that the average of rotating state productivity is 0.435 kg/m^2, which is higher than the average productivity for the fixed state that is 0.295 kg/m^2.

4. 3. Daily Productivity The water cumulative frequency, the total of the absolute frequencies of all events at or below a certain point in an ordered list of events, which was obtained from the solar still for both fixed and rotating states versus time is shown in Figure 6. This figure shows the daily productivity (amount of pure water from obtained from solar still during the day) of the rotating state is more than the fixed state. Another finding from this figure is the continuous increasing of produced water in the afternoon hours for rotating state,



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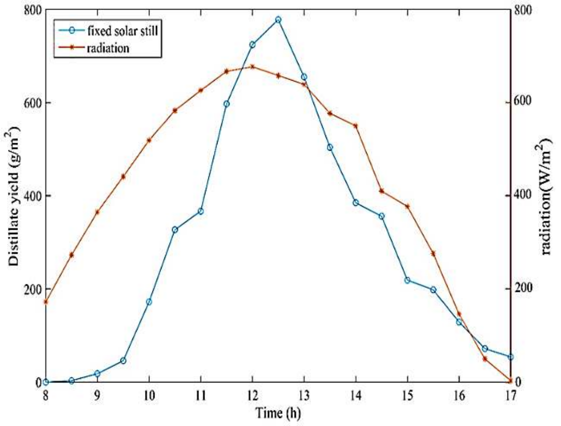

(b)

Figure 5. Distilled yield vs. time for the rotating state on 14 Nov. (a) and for the fixed state on 13 Nov.(b)

which can be due to the continuity of the sun intensity reflection from the reflectors on the lower glass area under the basin in rotating state. Table 3 illustrates some comparison of the daily productivity improvement amount by some researches in which using some kind of reflectors for increasing the productivity.

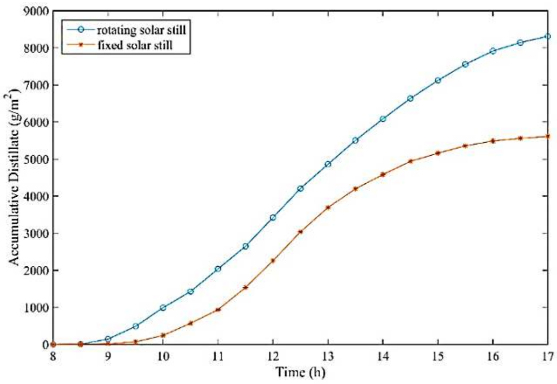

Figure 6. Water cumulative frequency obtained from solar still for the rotating state on 14 Nov. and for the fixed state on 13 Nov. vs. time

TABLE 3. Improvement in daily productivity of some researches regarding the solar still with reflector

Categorization	Authors	Latitude	Season of test accomplishment	improvement of daily yield	Test conditions
Basin type solar still	This study	32.4°N	Autumn	64.8%	Using three external bottom reflectors
Tilted wick solar still	Tanaka and Nakatake [6]	30°N	Winter	15%	Reflector's length is half of the still's length
				27%	Reflector's length is the same as the still's length
Tilted wick solar still	Tanaka and Nakatake [7]	30°N	Four days in four seasons	41%	Solar still is assumed to be rotated manually just once a day at southing of the sun.
Basin type solar still	Tanaka [11]	30°N	Spring equinox	41%	Using a flat plate external bottom reflector in addition to the internal reflector and setting the external reflector's inclination to the proper values according to the seasons
			Summer solstice	25%	
			Winter solstice	62%	

Comparing the reported data to this study showed that an increase in productivity in this study is more significant because of the effect of rotating and regular adjusting of the solar still and the reflectors.

4. 4. Cloudy Days For cloudy, semi cloudy or dusty days, the results indicated that the productivity of both the rotating and fixed state decreased as shown in Figure 7. Experimental observations showed that the solar radiation was weaker and nearly vertical from the sky in cloudy days and caused the reflectors, which were adjusted for a certain radiation angle, not to reflect the sun intensity on the lower glass area under the basin. The main difference between both the rotating and fixed states was the sun reflection from the reflectors and it was the main factor for increasing the productivity. Less solar radiation, less the difference between the productivity amounts of these two states. It was difficult to compare these two states in cloudy days because of there was no possibility of obtaining data in two days with the same solar radiation flux and atmospheric conditions. However, using the data of 30 Nov. for rotating state and 19 Nov. for the fixed state, which has almost the same atmospheric conditions (on 19 Nov. the solar radiation strength was less); one can nearly compare both states in cloudy and sunny days. Figure 7 shows this comparison for the cumulative abundant change of the obtained water from the solar still for the rotating and fixed states versus time. According to the obtained results, daily productivity for the rotating state is 3.771 kg/m^2 and for the fixed state is 2.042 kg/m^2 which comparing to the average daily production for both states in the sunny days, has decreased by 47% and 53%, respectively.

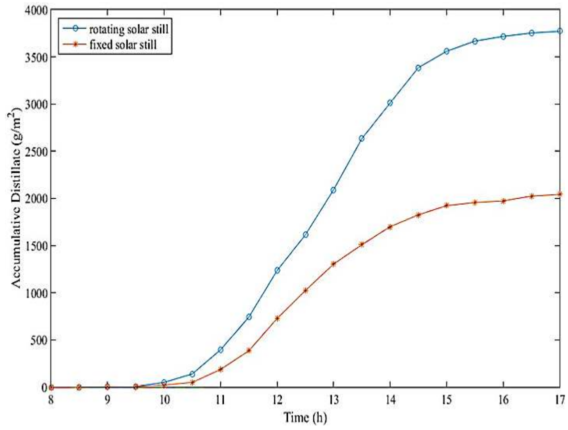

Figure 7. Cumulative of the obtained water from the solar still for the rotating state on 30 Nov. and for the fixed state on 19 Nov. vs. time

5. ECONOMICAL EVALUATION

Using a solar still should be reasonable, not to see only its high performance, but has to be the cost-effective. The cost of water production depends on a variety of factors, including maintenance costs, control systems and energy consumption. The cost of producing fresh water (C) can be obtained as follows [22-24]:

$$C = \frac{10I\left(\overline{IA} + \overline{MR} + \overline{TI}\right) + 1000\left(K_C + s\right)}{A\left(Y_D - Y_R\right)} \tag{1}$$

Where I is total capital invesment, $\overline{IA}$ is annual intrest and amoritization rate, $\overline{MR}$ is annual maintaince and repair labor and material, $\overline{TI}$ is annual taxes and insurance charges, K_c is operating and labor wage, s is total constant cost salt water supply, Y_D is annual unit yield of distilled water (Lm^{-2}), Y_R is annual unit yield of collected rain water (Lm^{-2}) and A is area of solar still (m^2). Since the solar still in the rotating mode needs an extra cost for rotating power and controling the collector direction, therefore one should consider them. Hence, a term (C_{ext}) should be added into Equation (1), follows:

$$C = \frac{10I\left(\overline{IA} + \overline{MR} + \overline{TI}\right) + 1000\left(K_C + s\right)}{A\left(Y_D - Y_R\right)} + C_{ext} \tag{2}$$

However, as mentioned earlier in this research, a manual system was used for rotating the collector angles on a regular basis, therfore parameter C_{ext} can be eliminated from Equation (2). As a result, one can find:

$$\frac{C_R}{C_F}=\frac{\dfrac{10I_R\left(\overline{IA}_R+\overline{MR}_R+\overline{TI}_R\right)+1000\left(K_{CR}+s_{CR}\right)}{A_R\left(Y_{DR}-Y_{RR}\right)}}{\dfrac{10I_F\left(\overline{IA}_F+\overline{MR}_F+\overline{TI}_F\right)+1000\left(K_{CF}+s_{CF}\right)}{A\left(Y_{DF}-Y_{RF}\right)}}$$

$$=\frac{\dfrac{1}{Y_{DR}}}{\dfrac{1}{Y_{DF}}}=\frac{Y_{DF}}{Y_{DR}}$$

$$Y_{DR}>Y_{DF}\rightarrow C_R>C_F$$

Since, all terms in the numerator are costs and they are the same for both states in this study and the area of the solar still remains constant for both cases. It is obviously, the terms of Y_D is different between two modes. Amount of water distilled in the rotating state is more than the fixed state. Therefore, the cost of producing water for rotating mode is less than the fixed state in this study.

6. CONCLUSION

The aim of this experimental research was to investigate the productivity of a basin solar still regarding its rotation and regular adjusting of reflectors to its fixed state.Therefore, three reflectors with the width equal to the basin of solar still under the solar still, and the lower area covered with the glass was used. The following results were obtained for the saline water with the thickness of 15 mm in the basin:

- The maximum temperature of the rotating state on 14 November was 79.2°C and for the fixed state on 13 November is 76.2°C. The average of basin water temperature is also higher during the day in the rotating state. This was 62.8 and 52.2°C for the rotating and fixed states, respectively.
- Average productivity of solar still in the rotating state has been increased 64% compared to the fixed state.
- The difference in productivity amount between the rotating and fixed states was decreased on cloudy days. In two days comparison, the daily productivity of rotating and fixed states has been decreased about 47 and 53% to the average of daily productivity of these states on sunny days, respectively.
- Ambient temperature and the obtained the solar radiation amount have a remarkable effect on the productivity of solar still in both fixed and rotating states. Therefore, the maximum productivity belongs to the solar noon; when the solar radiation and ambient temperature have the maximum amount.
- One can ignore adjusting the reflectors whose area is covered by shadow most of the time in a day.
- Input water, which has the same temperature as the solar still, decreases the productivity and suggested to make it warmer before entering the solar still for enhanced production.
- Feasibility study of solar stills in both states, due to the similar production costs, zero power consumption, and the surface area, the highest rate of fresh water produced in the rotating state.

7. ACKNOWLEDGMENT

The authors would like to acknowledge the Jundi-Shapur University of Technology for its supporting and providing lab facilities and necessary equipment.

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Performance of Rotating Solar Still with Rotating External Reflectors

RESEARCH NOTE

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PAPER INFO

Paper history:
Received 02 February 2019
Received in revised form 10 April 2019
Accepted 02 May 2019

Keywords:
Solar Still
External Reflectors
Solar Energy
Angle Shifting
Desalination

چکیده

در این تحقیق، یک آب شیرین کن خورشید چرخشی که از بازتابنده های بیرونی خارجی استفاده می کند، به صورت تجربی مورد بررسی قرار گرفت. آب شیرین کن خورشیدی و بازتابنده ها توانایی تغییر زاویه نسبت به جنوب و بازتابنده ها توانایی تغییر زاویه نسبت به افق را دارند. این آزمایش در حالت های ثابت و چرخشی انجام شده است. برای حالت ثابت، آب شیرین کن خورشیدی به سمت جنوب قرار گرفته است و بازتابنده ها به گونه ای تنظیم شده اند تا تابش خورشید را به سطح پایین حوضچه در ظهر بازتاب دهند. روز بعد، برای حالت چرخش، آب شیرین کن خورشیدی و بازتابنده ها هر نیم ساعت به صورت دستی تنظیم می شد تا تابش خورشید را در سطح پایین حوضه بازتاب و سیستم تقریبا همیشه به سمت خورشید هدایت می شد. آزمایش ها برای ۲۷ روز از نوامبر تا دسامبر انجام شد. نتایج روز آفتابی نشان داد که به طور متوسط آب مقطر با استفاده از حالت چرخشی حدود ٦٤٪ بیشتر از آب مقطر به دست آمده با استفاده از حالت ثابت بود. هر دو حالت چرخشی و حالت ثابت برای دو روز ابری با توجه به میانگین عملکرد روزهای آفتابی، به ترتیب ٤٧٪ و ٥٣٪ کاهش یافت.

***doi**: 10.5829/ije.2019.32.06c.13*