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Design of A Conical Solar Still (CSS) And Evaluation of Its Performance in Basra-Iraq

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ABSTRACT

In this research conical Solar Still (CSS) (with a circular basin) has been constructed and their performance has been evaluated under different atmospheric circumstances of Basra city (Iraq) (Latitude 30° 33' 56.55"N, Longitude 47° 45' 5.86"E). The conical solar still consists of a basin area of (0.0314 m^2). This small measurement has been adopted in the size (0.25 m) for the size of the conical glass cover and the difficulty of obtaining the larger measurement, this measurement of the conical cover is considered as the largest size for manufacturing obtained in Basra-Iraq. The maximum experimental efficiency of the experimental still varies from (58%) for the conical solar still.

Keywords: water; saline water; solar still; conical solar still; desalination

INTRODUCTION

The remote arid warm places in the Middle East and North Africa and other regions in the world are suffering from a sharp shortage of fresh water. These regions are characterized by high salinity of the ground water, lack of rains and a good solar energy. It is an international problem and the best solution, is the use of solar energy for desalination of salt water [1]. Brackish water (Saline water) represents very high percentage of the total water on the surface of the earth, (97% - 97.5%), and the rest is fresh water (3% - 2.5%), so the fresh water which is available for use is a very small fraction [2-7]. The desalination of saline waters requires a great amount of energy, so due to the energy crisis, new alternatives which are based on sustainable energy are essential to supplement the required energy of desalination processes. Over the years, solar energy has been used to purify water and numerous solar desalination devices have been developed. Solar stills directly utilize solar energy to desalinate brackish water and do not need other expensive and unsustainable energy sources such as fossil fuel. Therefore, they can be the best suitable solar desalination units to be used as low-capacity and self-reliant water supply systems [8]. Desalination processes require significant quantities of energy to achieve the separation of salts from seawater [9]. In oil-rich countries, about 95% of all freshwater is already supplied by desalination technologies using fossil fuels (oil or gas). In view of future oil shortages, desalination must, however, be driven by renewable energy [10]. G. Gowrisankar and R.Jayaprakash study a design of spherical solar still with the charcoal absorber and get a maximum efficiency which is (18%) for still without charcoal and (25.34%) for still with charcoal absorber [11]. Solar distillation is one of the available methods to produce potable water. This process has the advantage of zero fuel cost but requires more space (for collection) [12-13]. The Solar distillation is one of many processes that can be used to produce fresh water by using the heat of the sun directly in a simple equipment to purify water. The equipment is commonly called a solar still [14]. The aim of this work is to study the performance of new design conical solar still. And their performance has been evaluated under different atmospheric circumstances of Basra city.

MATERIALS, METHODS AND FILLERS

A Conical solar still has been constructed and their performance has been evaluated under different atmospheric circumstances of Basra city (Iraq) (Latitude 30° 33' 56.55"N, Longitude 47° 45' 5.86"E). Fig.1, shows the picture of Conical Solar Still. Figure (2) shows the schematic diagram of Conical solar still. The still has consisted of a circular basin with the area of (0.0314 m^2), the total height of the still is about 0.20 m. This small measurement has been adopted in the size (0.20 m) for the size of the conical glass cover and the difficulty of obtaining the larger measurement, this measurement is considered to cover a conical as the largest size for the manufacturing obtained in Basra-Iraq. The still consists of the circular basin of diameter 0.20 m, which is made up of Aluminum. The circular absorber basin is coated with black paint for maximum absorption of incident solar radiation. The circular basin is fixed on the base which is made up of aluminum, the distance between the basin and glass cover (1cm) was used to collect the distilled water. The evaporated water is condensed on the top cover creeps down towards the distilled water collection channel. It has been developed by putting a hollow screw of (8mm) in diameter on the channel to get distilled water linking transparent rubber tube in this screw, going to the distilled water collecting flask, a diameter of the plastic tube (1cm). The base of the still is insulated with pieces of wood (wood block) with the (1cm) thickness to avoid thermal losses to the external ambient, the basin was put and restricted on the base by silicon rubber. The experimental on the stills were carried out during some days of (August 2023) to study their performance under different field conditions. During each experiment, the hourly amount of extracted distilled water was monitored for still. The total daily amount of distillate water was recorded.

FIGURE 1: A photographic picture of the Conical Solar Still (CSS).

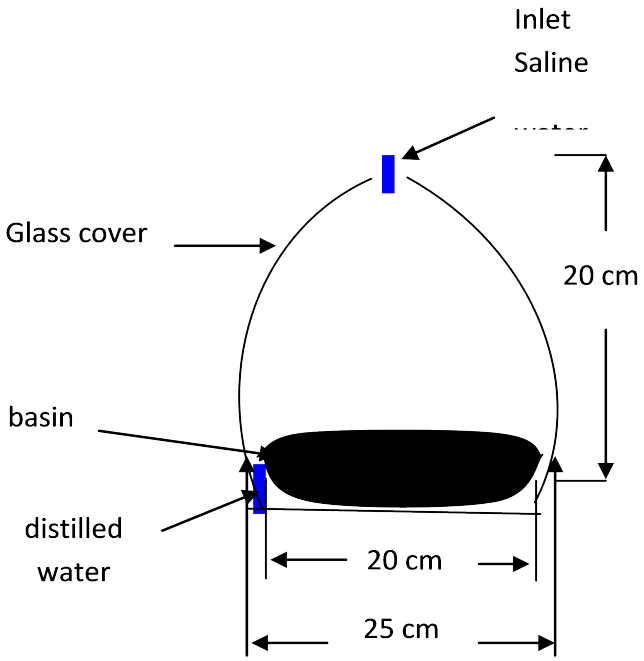

FIGURE 2: A schematic diagram of the Conical Solar Still (CSS).

RESULTS AND DISCUSSION

Figure (3) indicate the daily production of distilled water of the conical solar still throughout some days of August 2023. This figure shows that the daily production of the maximum value arrived to (5724 ml/m^2) for day (23/8/2023) where the sky is clear and the air does not contain the dust, where the production of the solar still has been depending on the intensity of solar radiation ,while the less value of production to (3657ml/m^2) on the day of (15/8/2023) where the sky is not clear but partly cloudy and the weather does contain on dust. Table (1) shows the recorded experimental production, solar radiation values, also temperatures for weather, glass cover, and basin of the conical solar still for day 8/23/2023.

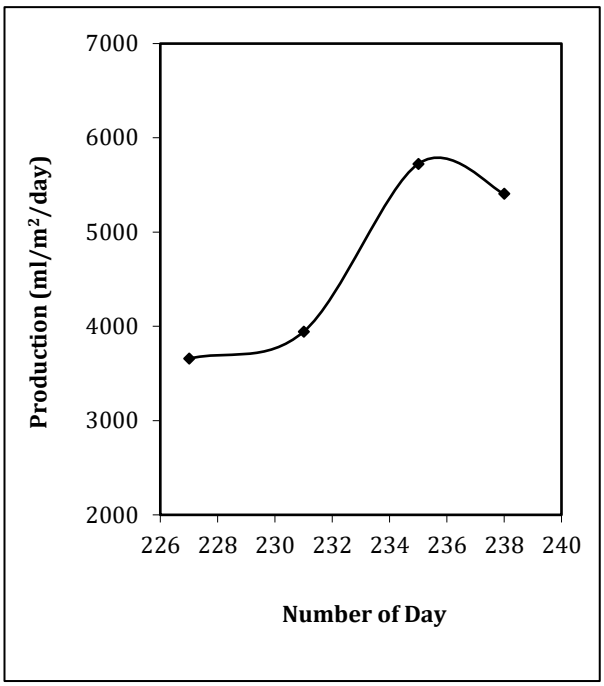

FIGURE 3: Daily productivity for the hemispherical solar still throughout some days of August 2023.

TABLE 1: shows the recorded experimental production, solar radiation values, also temperatures for weather, glass cover, and basin of the conical solar still for day 8/23/2023.

Time of day (hr.)	T_w (C°)	T_g (C°)	T_a (C°)	Exp. Water production (ml/m²/hr.)	I(W/m²)
8.00	47	55	60	127.2	612.48
9.00	48	56	65	159	790.21
10.00	49	57	68	318	850.61
11.00	50	58	70	477	890.78
12.00	52	60	79	795	880.7
13.00	52	61	80	1049.4	750.3
14.00	52	60	75	1049.4	634.57
15.00	51	58	70	954	433.77
16.00	49	52	65	636	280.15
17.00	48	49	60	159	148.3
Sum				**5724**	**6271.8**

The product water is measured hourly by calibrated beaker of 1-liter volume. The productivity of the still with respect to the solar radiation has been studied. The results of the day 23 of August and 15 August, 2013 are shown in fig. 4. The average daily production of the conical solar still has the same behavior and the variation in its productivity from one day to another depending on the variation in solar radiation and the other meteorological factors like clouds. It is clear from the figure that the productivity of the still has the same behavior with respect to the solar radiation behavior. A maximum production is at midday while a lower one is at the first and the end day hours, but there is a significant increase in the productivity of the conical solar still at the midday hours of the day because the inner surface is conical and has a wide area. Productivity of the solar still has been increased due to increase in temperature difference between water surface and inner surface of condensing glass cover. The maximum value arrived to (1049 ml/m^2) in the hour (13 pm) while lower value arrived to (90 ml/m^2) in the hour (17 pm).

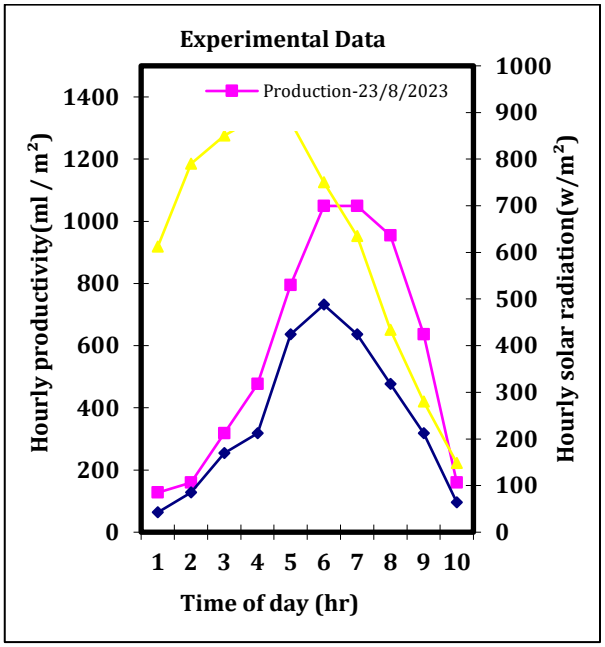

FIGURE 4: Hourly productivity of the conical solar still with solar radiation during the day of (15 Aug. and 23 Aug.) 2023.

Figure (5) shows the daily production of distilled water of the conical solar still with the solar radiation through some days of (August 2023). This figure shows that the daily production has a maximum value arrived to (5724 ml/m²) for the conical solar still the day 23 August 2023, where the sky is clear (there is no dust), where the production of the solar still has been depending on the intensity of solar radiation. While the daily production has a minimum value arrived to (3657 ml/m²) for the conical solar still the day 15 August 2023.

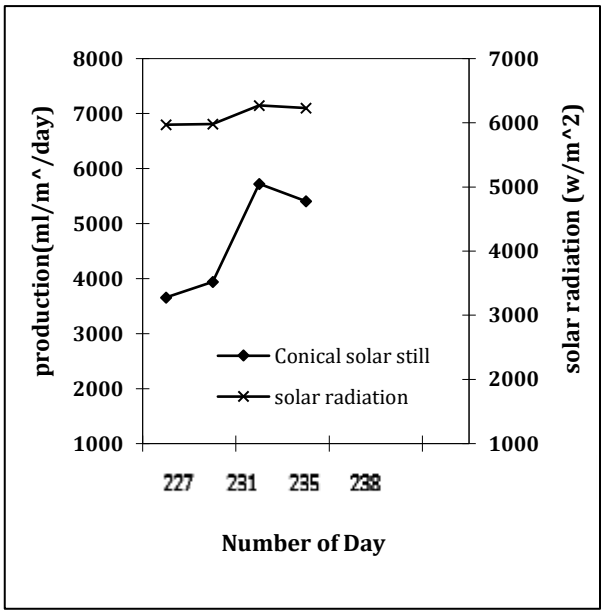

FIGURE 5: Daily productivity for the conical solar still with the solar radiation through some days of (August 2023).

The thermal efficiency (E) of the still was calculated for some days using the following equation [15].

$$E_{bsn} = \frac{P \times L}{I \times A_b} \times 100\%$$

Where:
Ebsn: Thermal efficiency.
P: Daily output of distilled water.
L: Latent heat of water evaporation (KJ / Kg).
I: Daily solar radiation (W / m². day).
Ab: Area of the basin if the still (m²).

Figure (6) shows the thermal efficiency (E) for the conical solar still and through some days of (August 2023). The maximum thermal efficiency arrived at (58%) for conical solar still for the day 23 August 2023 while a minimum value of the efficiency for the day 19 August 2023 is (39 %).

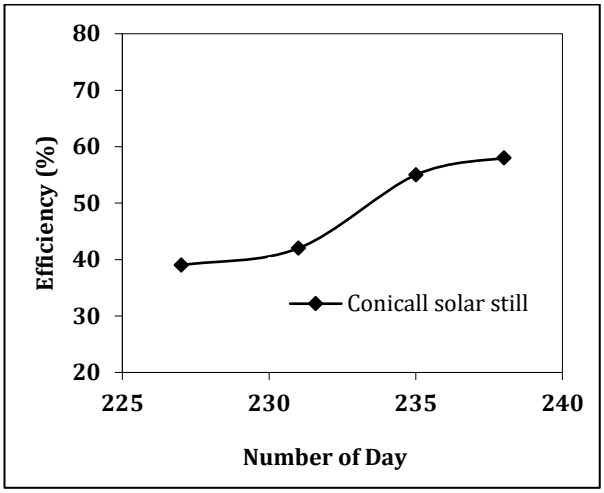

FIGURE 6: Thermal efficiency of the conical solar still through some days of (August 2013).

CONCLUSIONS

The main observations and conclusions that can be obtained from the results of this work are the following:
The largest part of distillate production was seen to take place between noon and sunset, where the productivity was increased with the increase of solar radiation. The average daily production of the conical solar still has the same behavior and the variation in its productivity from one day to another depending on the variation in solar radiation and the other meteorological factors like clouds. The maximum thermal efficiency arrived at (58%) conical solar still for the day 23 August 2023. The distillate production can be increased when the temperature of the brackish water increases.

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