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Experimental investigation of corrugated absorber solar still with wick and reflectors

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HIGHLIGHTS

- The performance of a corrugated wick solar still and reflectors still are investigated.
- The corrugated plate as the base increases the amount of distilled water produced by about 55.36%.
- The productivity of a corrugated wick still with reflectors is about 145.5% higher than conventional still.

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ABSTRACT

The performance parameters of the corrugated solar still (CrSS) and conventional solar still (CSS) are investigated experimentally from another point of view. The authors' view concerns with using the double layer wick material and also reflectors together inside the CrSS. In addition, the influence of saline water depth (1, 2, and 3 cm) on CrSS performance was also investigated. Results indicated an enhancement in the total productivity and efficiency of the CrSS. During experimentations, the productivities of CrSS with wick and reflectors are about 145.5% higher than the CSS, at a brine depth of 1 cm, and the daily efficiency of CrSS and CSS are approximately 59% and 33%, respectively.

1. Introduction

In the remote areas, people struggle to get pure water at a low cost. For this problem, solar desalination using still is the sustainable solution. Basin still is easy to fabricate and simple, but not economical due to its lower productivity. To increase the production, different designs were tried; corrugated absorber solar still is one such type.

A survey of various solar still desalination systems was made by Gang Xiao et al. [1] and Sivakumar and Sundaram [2]. Many attempts have been prepared and done to increase the yield of solar stills with lower costs. The basin area of the still, free surface area of the water, depth of the water in the still and inlet water temperature are considered as the main factors affecting the productivity of the solar still.

The productivity of the basin liner, solar still increases with increasing surface areas of the solar still base. Corrugated base, fins and sponges were used to increase the base area [3,4,5]. Velmurugan et al. [3] added the fins at the basin of the still and their results showed an increase of daily productivity from 1.88 to 2.8 kg/m^{2}d compared to that of the other types. In addition, Velmurugan et al. [4] modified the fin solar still with black rubber, pebble, sponge and sand for enhancing its productivity. Their results indicated that the maximum increase of distilled output yield of 75% occurred, when the fin type solar still was integrated with sand and sponge. An experimental work to study the effect of using finned and v-corrugated basin liners on the performance of solar stills was conducted by Omara et al. [6]. Their results showed that the yield of the corrugated and finned solar stills was enhanced, at a constant quantity of saline water of 30 l, by 21% and 40% respectively. In addition, the daily efficiency for corrugated, finned and conventional solar stills reached about 41%, 47.5% and 35% respectively.

The air subjected to natural convection inside the solar still will take more amounts of water particles, when the surface area of basin water is high. The water wets the surface of the materials available in the basin and exposed to a larger area and ready for diffusion. Kalidasa and Srithar [7] used different wick materials in the basin of a double slope solar still to increase the surface area of evaporation of water. Sakthivel et al. [8] used a vertical jute cloth at the middle of the basin of a regenerative

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solar still to increase thermal performance of the solar still. The advantage of the wick is to keep the brine as shallow as possible while avoiding dry spots. So, to improve the performance of the solar still, wicks are used [9–11].

The internal reflectors are used to enhance the performance of solar stills [12–14]. The reflectors reflect a fraction of the radiation onto the water surface. This consequently increases the water temperature of solar still and the internal reflectors minimize the amount of energy lost.

Limited studies were made on the improvements of corrugated still. So, the main objective of the present experimental study is to enhance the yield of corrugated solar still by two modifications, using a double layer wick material and internal reflectors. In addition, under the same climatic conditions a comparison between CrSS and CSS is conducted to evaluate the desalination system performance.

2. Experimental set-up

The experimental setup consists of CrSS, CSS and saline water tank. Fig. 1 shows a detailed cross-sectional view of the tested solar stills. The stills are made from galvanized iron sheets of 1.5 mm thickness. The stills are designed, fabricated and installed facing the south direction to evaluate the performance of the distillation unit. The base and side walls are insulated by fiberglass with 30 mm thickness to make the thermal losses minimum as possible. The basin was covered by a commercial clear glass sheet of 3 mm thick inclined at nearly 30° horizontally, which is the latitude of Kafrelsheikh, Egypt. The size of the absorber plate of the conventional still is 0.5 m^2, Fig. 1a.

The corrugated solar still, Fig. 1b, has the same dimensions of the CSS. In addition, the base of corrugated still is shaped as waves; each has a height of 50 mm with an angle of 80° between any two tops or any two bottoms. Fig. 2 shows photos of the corrugated solar still, and its modifications. Using the double layer wick material over the corrugated absorber is the first modification, Fig. 2a. While, the second modification is involving the installation of mirrors on the three shining walls inside the corrugated still, Fig. 2b.

3. Experimental procedures

The experimental investigations were tasted for twenty-seven days during May and July 2014 at Kafrelsheikh University, Egypt (latitude 31.07° N and longitude 30.57° E). Experiments were carried out in the outdoor environment. Each experiment was performed for one day. All measured data are collected and recorded every 00 hour, starting from about 9:00 AM to sunset. The accumulated productivity during the day is also measured for each experiment. Each experiment is performed for one day. An atmospheric, glass and basin temperatures, distilled water productivity and the solar radiation were measured every one hour. In addition, the accumulated freshwater productivity during the twenty-four hours is measured in each experiment.

The performance of the different solar stills is experimentally investigated under three cases: corrugated still only, corrugated still with wick, and corrugated still with wick and reflectors. The performance

a. Corrugated solar still with wick

b. Corrugated still with wick and reflectors

Fig. 2. Corrugated solar still.

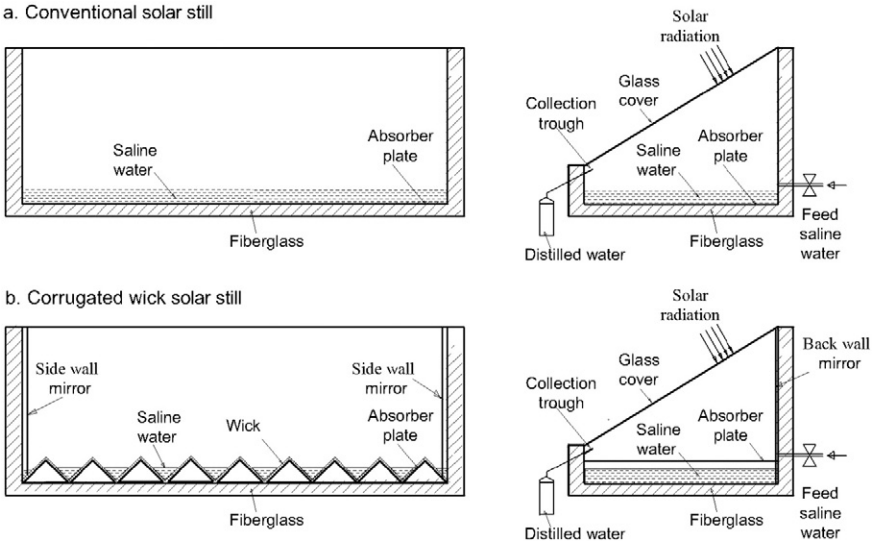

Fig. 1. Cross-sectional view of solar stills.