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The performance of a modified solar still using hot air injection and PCM

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HIGHLIGHTS

- A solar air collector-coupled modified solar still with phase change material have been investigated
- A comparison between modified still with and conventional still is carried out
- The augmentation of freshwater productivity for modified still reached 109 % compared to conventional still

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ABSTRACT

A double passes solar air collector–coupled modified solar still, with Phase Change Material (PCM), have been experimentally investigated to enhance the freshwater productivity. The influence of the injected hot air on the performance of a modified still, with PCM, is investigated. A comparison between a modified still, with both PCM and hot air injection, and the conventional still is carried out to evaluate the enhancement in the freshwater productivity. The experiments were carried out under the same atmospheric conditions. The experimental results show that, the freshwater productivity approximately reached 9.36 (L/m^2 day) for the double passes solar air collector–coupled modified solar still, with PCM, while its value is recorded 4.5 (L/m^2 day) for the conventional still. The freshwater productivity of the double passes solar air collector–coupled modified solar still with PCM is 108% higher than that of the conventional still on average. This percentage is obtained during the period from June to July 2015 under the Egyptian climatic conditions.

1. Introduction

Freshwater represents an important element for all organisms that live on the surface of the globe, as well as an important element in the development of industry. The percentage distribution of the water on the earth is 2.53% and 96.54% of freshwater and seawater, respectively [1], and the available fresh water for the people is 0.36% of total fresh water [2]. As a result of the continuous increase in population and the rapid development of industry, supply of fresh water has become a problem facing many different areas on Earth. One of the options used to obtain fresh water from seawater is to use solar desalination system. Solar stills represent a good option and a simple technique compared to the other distillation methods.

Reflectors are used to increase the amount of the solar radiation absorbed by the absorber surface of still. Hiroshi Tanaka [3] studied the impact of internal and external reflectors on the still performance; the results were compared with that of the conventional still. This study showed that, using internal and external reflectors increases the productivity in the range from 70 to 100%. Omara et al. [4] experimentally studied the impacts of external and internal reflectors on the behavior of stepped still and compared their results with the conventional still. They concluded that, the daily productivity of the stepped still with reflectors is increased by 125% compared to still without reflectors. Dev et al. [5] studied the impacts of a curved reflector on the performance of solar still at different water depths. They found that the productivity of still with curved reflector were 4.3, 5.6, and 6.3 (L/m^2 day) at the following saline water depths 3, 2, and 1 cm respectively.

Solar stills are one of the methods used in desalination of seawater using solar energy. Where, solar stills give a low productivity, many research work is devoted to increase the productivity of solar stills [6–8], a merged solar collector with basin still is adopted in those studies. The performance of a solar collector with hot water storage tank coupled with basin still was extensively studied [9–10]. Abu-Hijileh Bassam et al. [11] use the sponge cubes in the basin water to increase the free surface of the saline water, their results showed an improvement in the distillate water productivity. The use of the sponges in a single basin still and stepped still improved the productivity by 15.3% [12–14].

Some techniques that could be used to enhance the productivity of still are the use of phase change materials as a heat storage medium.

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The impact of phase change material (PCM) on the productivity of a basin still and stepped still is also studied by many researchers, [15–16]. Mohammad Dashtban et al. [17] studied the effect of PCM on the performance of cascade still. Arunkumar [18] studied the effect of PCM on the productivity of the concentrator–coupled hemispherical basin still. The results show that, the freshwater productivity with PCM is 26% higher than that without PCM. G.C. Pandey et al. [19] studied the effect of air bubbling and cooling of glass on the performance of solar still. They found that, both the continuous bubbling of air and glass cooling give a higher increase in the productivity. Gyorgy Mink et al. [20] experimentally studied the performance of air blown still with heat recycling. These studies showed that, the freshwater productivity of the new still is higher than that of the conventional still.

The objective of the present work is to study the enhancement of the freshwater productivity of the solar still by using the double passes solar air collector–coupled modified solar still with PCM. The PCM acts as latent and sensible heat storage medium. The used PCM in the current work is the Paraffin wax due to its wide availability and low cost. The effect of hot air injection on the performance of modified still with PCM is experimentally investigated, and the study results are compared with conventional still, to evaluate the enhancement in the freshwater productivity when using forced hot air injection and PCM.

2. Experimental setup

In the current work, two solar stills were designed, fabricated and constructed to compare the distillate water productivity by using the solar desalination technique. One of the stills is the modified solar still, with PCM, integrated with a double passes solar air collector, and the other is the conventional solar still as shown in Figs. 1 and 2.

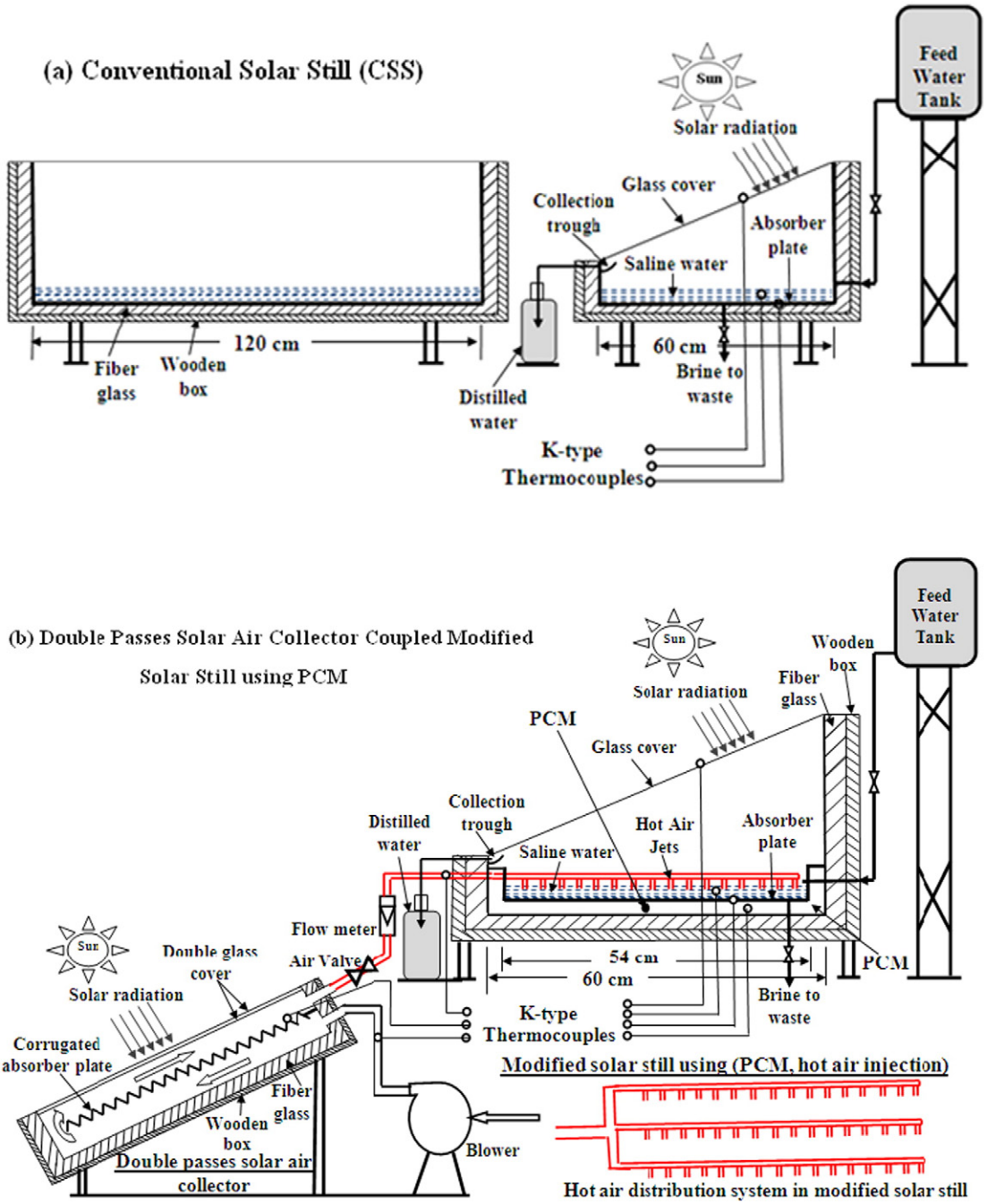

Fig. 1. Schematic diagram of the double passes solar air collector–coupled modified solar still with PCM and conventional solar still.