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A solar still augmented with a flat-plate collector

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Abstract

A single-stage, basin-type solar still and a conventional flat-plate collector were connected together in order to study the effect of augmentation on the still under local conditions. The still inlet was connected to a locally made, fin-tube collector such that its outlet was fed to the still basin instead of the common storage tank. Measurements of various temperatures, solar intensities and distilled water productions were taken for several days at various operating conditions. Several modes of operation were studied: still connected to collector for a 24-h period; still connected only during sunlight hours from 8 am to 5 pm, and still operating alone for a 24-h period. These tests were performed using tap water and saline water as a feed. It was found that the mass of distilled water production using augmentation was increased by 231% in the case of tap water as a feed and by 52% in the case of salt water as a feed.

Keywords: Solar distillation; Augmentation; Flat-plate collectors

1. Introduction

Several types of solar stills exist, the simplest of which is the single-basin type. But the yield of this still is in the range of 2–4 L/d per m^2 of still area [1], which is very limited. There are, however, several methods to augment this yield, which generally fall into two categories: concentrators and flat-plate collectors. This system, also called the "active" system [1], is probably appealing for countries such as Jordan where flat-plate collectors are already being installed in increasing numbers. All that is needed is to "add-on" a solar still to an already existing collector and obtain an extra amount of distilled water at no extra cost to the still.

In this work, the effect of adding a conventional-type solar collector to a single-stage basin-type solar still was investigated. The results of this augmentation on the performance, productivity and efficiency of the still under the climatic conditions of Jordan are shown. The efficiency of a single-basin still was compared with the effi-

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ciency of the collector-still system, and a similar comparison was made in each case between the produced quantities of distilled water.

The concept of still augmentation by flat-plate solar collectors was first introduced by Zaki et al. [2] in 1983. They studied an active system of single-slope-type stills integrated with a flat-plate collector under the thermosyphon mode of operation. They found that the maximum increase in the yield was up to 33% when the water in the still was preheated in the collector.

Al Baharna et al. [3] analyzed the performance of a triple-basin still integrated with a solar collector. They found that the daily distillate was more than double compared with that of the still alone.

Although it has been shown that the overall efficiency of a passive solar still is higher than that of an active one due to the lower range of operating temperatures [4–6], the concept is still appealing in situations where the collectors are already available. Recent works [7,8] indicate that research is still active in the area, with more emphasis on multi-effect desalination connected to solar collectors. Another recent work [9] reports that a productivity of 25 L/m^2.d was reached using such a system.

There are, however, recent works [10–12] that investigated similar systems that were integrated with storage tanks. It was found that coupling a solar still to a hot water tank generally doubles the distilled water output within a 24-h period [10].

2. Experimental

The experimental set-up is one kind of a so-called active distillation system [1] where a conventional solar still is assisted by another heat source. In this case the source is a flat-plate collector. A photograph of the still-collector system is shown in Fig. 1, and a sketch of the

Fig. 1. Photograph of the still-collector system.

device is shown in Fig. 2. The set-up was assembled from existing, locally made components: a basin-type still with a double-slope glass roof, a conventional fin-tube flat-plate collector, a constant head tank and a feeding tank.

The still was made of a square basin, 960× 960 mm, and a 20-mm water depth. The basin was insulated with 30 mm of rock wool of 0.0346 W/m°C thermal conductivity. The glass roof was a pyramid-like shape of 4-mm thickness. The sides were sloped at 45°.

The collector was made of seven parallel tubes with a 12 mm inside diameter with 100-mm spacing. The tubes were fixed to 0.7-mm thick, steel-plate coated by ordinary black matte paint. The area of the collector was 1.34 m^2. It was fixed at an angle of 45° with the horizontal facing due south.

A constant head tank, 500×500×300 mm was used to control the level of water inside the still by a float installed at the tank's inlet. A feeding tank 400×400×600 mm was used to compensate

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