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Effect of water depth on internal heat and mass transfer for active solar distillation

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Abstract

In this communication, an attempt has been made to find out the convective heat transfer coefficient for active solar distillation system. It is a well-known fact that the distillate output (the yield) decreases significantly with the increase of water depth in the basin of the solar still. It is also known that more yield is obtained in case of active solar distillation system as compared to passive solar still due to higher temperature difference between the water and inner glass cover temperatures in the active mode. For the present study, experiments have been conducted for 24 hours during winter months for different water depths in the basin (0.05, 0.1 and 0.15 m) for passive as well as active solar distillation system. The objective of the present paper is to study the effect of different water depths in the basin on the heat and mass transfer coefficients. It is inferred that the convective heat transfer coefficient between water and inner condensing cover depends significantly on the water depth in the basin. It is also observed that more yield is obtained during the off shine hours as compared to daytime for higher water depths in solar still (0.10 m and 0.15 m) due to storage effect.

Keywords: Solar distillation; Heat and mass transfer coefficients

1. Introduction

The process of solar distillation is used to distill brackish/saline water by using solar energy. The systems involved in solar distillation operate under two modes: passive and active. Malik et al. [1] reviewed the work done on passive solar stills until 1982. Kiatsiriroat et al. [2] analyzed the performance of a multiple-effect vertical solar still with a flat-plate solar collector. Zaki et al. [3] experimentally investigated concentrator assisted solar stills. Tiwari [4] reviewed the work on passive as well as active solar stills. Later Kumar and Tiwari [5] estimated the convective mass transfer for passive solar distillation systems. Recently Tiwari et al. [6] have studied the convective heat transfer coefficient for a passive/active solar still by using inner glass

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cover temperature for a limited period of operation, but they did not consider different water depths in the basin to calculate the convective heat transfer coefficient. Further, Tiwari et al. [7] reviewed the present status of research work on both passive and active solar distillation systems. Delyannis [8] presented an historical background of desalination and renewable energies.

From earlier published works on solar distillation, it has been observed that the passive solar distillation system is a slow process for the purification of brackish water. This process can be significantly increased in an active mode of a distillation system [6], due to the fact that additional thermal energy is fed into the basin from a collector panel [2,3]. Hence there is a strong need to have a basic knowledge of heat and mass transfer coefficients in detail for an active solar still. In this communication, an attempt has been made to study the effect of different water depths in a solar still on the heat and mass transfer coefficients for the passive as well as the active mode.

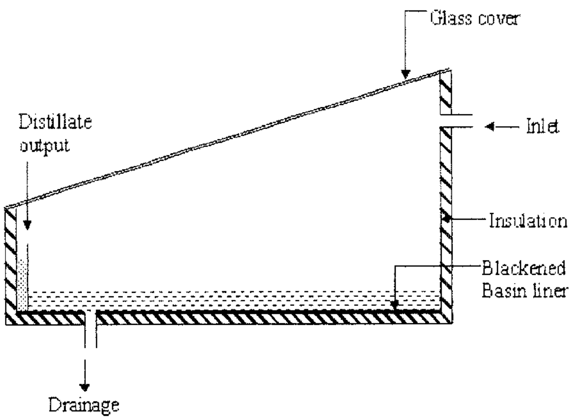

Fig. 1a. Cross sectional view of a single-slope passive solar still.

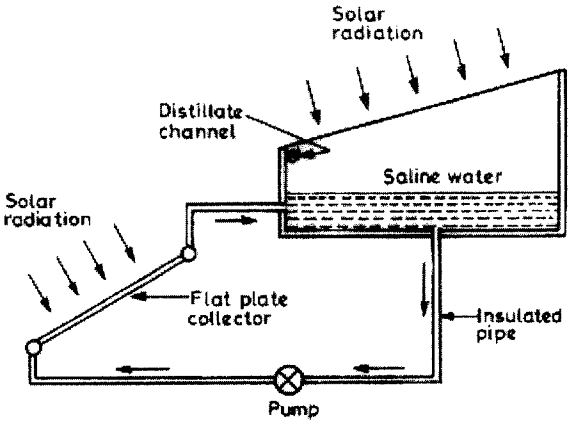

Fig. 1b. Schematic diagram of an active solar still coupled with a flat-plate collector.

2. Experimental procedure and observations

A cross sectional view of a single-slope passive solar still made of fibre-reinforced plastic (FRP) is shown in Fig. 1(a). The bottom surface of the still was painted black for greater absorptivity and a glass cover 3 mm thick covers the still. Fig. 1(b) shows the schematic diagram of an active solar still coupled with a flat-plate collector (FPC). The area of the still and FPC was taken as 1 and 2 m^2, respectively.

The hot water from the collector was pumped into the basin of the still to increase the temperature difference between the glass and water surface. The pump was operated only during the sunshine hours, i.e., from 9 am to 4 pm, and was kept off during off-sunshine hours to avoid heat losses caused by reverse flow. The storage effect was studied by filling the basin of the solar still with water at different depths: 0.05 m, 0.10 m and 0.15 m. This led to the average spacing between the water surface and the glass cover to be kept at 0.255 m, 0.205 m and 0.2 m, respectively. The following parameters were measured every hour for a period of 24 h for different depths and different modes of experimentation:

- water temperature
- inner glass temperature
- outer glass temperature
- vapor temperature
- total radiation on the glass cover and on the collector