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Characteristic equation of a passive solar still

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Abstract

The characteristic equation has been used for experimental results of a passive solar still to generate linear and non-linear characteristic equations for winter and summer conditions. The different angles of inclination of condensing cover (15°, 30°, 45°) have been chosen for winter and summer conditions both. It has been observed that the passive solar still with inclination of 45° gives better performance both in winter and summer respectively. Different water depths (0.04, 0.08, 0.12, and 0.16 m) have also been taken for solar still with 30° inclination angle for summer weather condition. Comparisons of instantaneous gain and loss efficiencies at 0.01 and 0.04 m water depths for a 15° inclination angle have also been made to show the effect of water depth on the performance of solar stills. It was found that a lower water depth gives better efficiency, which is in agreement with many investigators. The instantaneous gain and loss efficiency curves have been simultaneously analyzed to give a better understanding of the performance of solar stills. The proposed method will be used to standardize the design and operational parameter of a passive solar still, i.e. angle of inclination and water depth for highest yield for a given climatic condition.

Keywords: Solar energy; Solar distillation; Passive solar still; Instantaneous efficiency

1. Introduction

The availability of fresh water is decreasing from the natural resources due to water pollution and the receding level of underground water all over the world. Solar distillation is an economical, effective and environmentally friendly method over all the conventional distillation methods (which are energy and cost intensive techniques) for getting the pure water through the use of solar energy.

The performance of solar distillation systems depends on climatic parameters such as ambient temperature, solar radiation intensity and weather condition etc., design parameters like inclination angle and operational parameters like orientation of solar still and brine water depth [1]. It has been

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found that with the increment in solar radiation intensity [2] and ambient temperature, the productivity of the solar still increases [2,3]. Many investigators proved that increasing the brine water depth in solar still basis reduces daily productivity [4–6].

An extensive review of various types of solar stills was updated by Tiwari [7]. The performance evaluation of passive solar still in terms of yield/m^2 has been studied by Tiwari and Tiwari [8]. It was concluded that the annual yield is maximum for 30° inclination of the condensing glass cover on the basis of the monthly yield. However, it is important to mention that the system should be designed by using the concept of efficiency. The first attempt to characterize the performance of a solar still was made by Tamimi [9]. The broad domain of characteristic curves of solar stills between an ideal condition and the worst condition have been analyzed. The concept of instantaneous thermal efficiency to characterize designs of solar still including trapezoidal cavity system was introduced by Tiwari and Noor [10]. The first attempt to plot the characteristic curve for one-sided vertical solar stills was made by Boukar and Harmim [11].

Tsilingiris [12] has studied the influence of binary mixture thermo-physical properties in the analysis of heat and mass transfer processes in solar distillation systems. Various equations for heat transfer coefficient and other properties of water vapor mixture have been developed. It was found that variation in values of heat transfer coefficients is almost constant till 60°C; thereafter at higher temperature these values change considerably. A group of improved heat and mass transfer correlations in basin type solar stills has been developed by Hongfei et. al. [13]. Torchia-Núñez et. al. studied the exergetic analysis of a passive solar still [14]. It was found that for the same exergy input, a collector (basin), brine and solar still have exergy efficiencies of 12.9%, 6% and 5% respectively. An experimental validation of thermal modeling of solar stills on the basis of heat transfer coefficients for summer and winter conditions has been presented by Shukla and Sorayan [15]. A study on water evaporation area for increasing the yield in a solar still was carried out by Kwatra [16]. In this study a relationship between enlarged evaporation area and distillate by computer simulation was obtained. It is shown that a gain of 19.6% in a yield when the evaporation area was quadrupled. For an asymptotic (infinite) area, a 30.2% increase in gain was found. The thermal dynamic effects of material used for manufacturing solar stills in combination with weather parameter has been studied by Porta et al. [17].

In the present work, the effect of inclination angle on instantaneous efficiency of single slope solar still for summer and winter conditions of New Delhi has been analyzed. The effect of water depth on instantaneous efficiency has also been studied for summer conditions. The inclination angles of condensing cover were taken as 15°, 30° and 45° for a water depth of 0.04 m. For a 30° inclination angle, water depth was taken as 0.04, 0.08, 0.12, and 0.16 m alternatively. And for a 15° inclination angle, water depth was taken at 0.01 and 0.04 m. Experimental data collected for June 2004, November 2004 and April 2005 are used for the analysis [18].

The aim of the present work is to get a better understanding of the performance of passive solar stills through characteristic curves for summer and winter weather conditions.

2. Experimental set-up and observations

A photograph of the experimental set-up of a single slope passive solar still with different inclination angles of the condensing cover (15°, 30°, 30°, 45°) is shown in Fig.1(a). The schematic diagram of the passive solar still is also shown in Fig. 1(b). The set-up is installed at Solar Energy Park, Indian Institute of Technology, New Delhi (latitude 28°35′ N, longitude 77°12′ E,