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RESEARCH ARTICLE

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Experimental study on performance of passive and active solar stills in Indian coastal climatic condition

Abstract This present work is aimed to examine the effect of mass flow rate on distillate output and performance of a solar still in active mode. Outdoor experiments were conducted at the coastal town, Kakinada (16°93′N/83°33′E), Andhra Pradesh, India. A solar still with a 30° of fixed cover inclination, 1 m^2 of effective basin area, and a flat-plate collector (FPC) with an effective area of 2 m^2 were used. An attempt was also made earlier in passive mode to optimize the water depth for the same solar still for maximum yield and distillation efficiency. For the passive still, it is observed that the capacity of heat storage and heat drop are significant parameters that affect the still performance. For the selected still design, the study reveals that 0.04 m water depth is the optimum value for specific climatic conditions. In the active solar still, with the optimum water depth, different flow rates of 0.5, 1 and 1.5 L/min are considered through FPC. It is observed that both the mass flow rate and the variation of internal heat transfer coefficients with the mass flow rate have a significant effect on the yield and performance of the still. The experimental results show that the combination of 1.5 L/min mass flow rate and an optimum water depth of 0.04 m leads to a maximum yield for the active solar still. The enhanced yield of the active solar still is 57.55%, compared with that of the passive solar still, due to increase in area of radiation collection and more heat absorption rate.

Keywords distillation efficiency, solar still, heat transfer coefficient, water depth, optimum and mass flow rate

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1 Introduction

Many processes are available for obtaining purified water in which distillation is one of them. During this process water gets heated and evaporated. This evaporated vapor will be condensed and pure water is formed. The required heat for the process is powered from the Sun. In Indian coastal regions, potable water may not be readily available and ground water is mostly used as drinking water. By considering the availability of solar energy and ground water, the practical alternative, a solar distillation of ground water especially in Indian costal conditions, was studied.

This type of solar distillation never demands any hidden fuel costs and is eco-friendly. The solar radiation is abundantly available in India compared to its effective usage. So the capacity of distillation can be raised by increasing the area which receives solar radiation. There are two types of solar distillation systems, namely the passive and the active solar system.

1.1 Definition of the problem

The internal heat and mass transfer processes affect the performance of solar distillation unit. Dunkle [1] proposed a relation between internal heat and mass transfer coefficients. A wide variety of solar stills with different geometries for different climatic conditions and different modes (passive and active) were analyzed based on Dunkle's relation.

For the selected design, an attempt was made in this paper to find an optimum water depth required in the still for maximum daily yield. Various water depths such as 0.02 m, 0.03 m, 0.04 m, 0.05 m, and 0.06 m were considered for performance prediction of the unit.

This paper also described an attempt to compare various mass flow rates of an active solar still for maximum yield for the selected design. Three different mass flow rates of 0.5 L/min, 1 L/min, and 1.5 L/min were considered for an active solar still. The convective mass transfer relations