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Effect of climatic, design and operational parameters on the yield of a simple solar still

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Abstract

This paper reports the use of a mathematical model to predict the productivity of a simple solar still under different climatic, design and operational parameters in Oman. The shallow water basin, 23° cover tilt angle, 0.1 m insulation thickness and asphalt coating of the solar still were found to be the optimum design parameters that produced an average annual solar still yield of 4.15 kg/m² day.

A cost analysis is performed to shed some light on the potential of utilizing an array of simple solar stills for the production of drinking water in remote areas in Oman. It was found that the unit cost for distilled water obtained from such an array of solar stills is \$74/1000 gal. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Solar still; Design and operational parameters; Numerical modeling

1. Introduction

The presence of water is an important element in the development of the economy and the welfare of any nation. One of the major concerns in the third world at present is to find new resources and new processes of providing cheap fresh water, especially for people in remote areas. Desalination systems use traditional fuels in many countries of the world and in particular in the Middle East and the Gulf states where water resources are very scarce. The use of solar energy in desalination systems is gaining more momentum especially in the Gulf region where the solar radiation intensity is very high.

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Nomenclature

C	specific heat (J/kg K)
h	convection heat transfer coefficient (W/m ² K)
I	hourly incident solar radiation (W/m ² h)
L	length (m)
k	thermal conductivity (W/m K)
Nu	Nusselt number
P	pressure (Pa)
Pr	Prandtl number
q	heat flux (W/m ²)
Q	heat (W)
Ra	Rayleigh number
Re	Reynold number
T	temperature (°C)
U	overall heat transfer coefficient (W/m ² K)
α	absorptivity
δ	declination angle
θ	angle between direction of air flow and normal to surface
Φ	relative humidity
ε	emissivity
ν	kinematic viscosity (m ² /s)
τ	transmissivity

Subscripts

a	air
b	basin, beam component of solar radiation
c	convection
d	diffuse component of solar radiation
ev	evaporation
g	glass
r	radiation
w	water

Numerous experimental and numerical investigations have been done on classical types of solar stills, such as those of Mowla and Karimi [1], Dunkle [2], Abu-Hijleh [3], Al-Abbasi et al. [4], Hamdan et al. [5], Badran and Hamdan [6] and Singh and Tiwari [7]. An extensive review paper on solar desalination systems has been published by Kalogirou [8].

The aim of the present paper is to report a parametric study on the performance of a simple solar still under the Sultanate of Oman climate. Moreover, a cost analysis is performed to shed some light on the feasibility of using an array of such type of solar stills for production of drinking water in remote areas.

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