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Modelling and performance analysis of a regenerative solar desalination unit

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Abstract

In this paper, a regenerative solar desalination unit is modeled and its performance evaluated. The unit consists of two basins (effects), with provision for cooling water to flow in and out of the second effect. This arrangement has the advantages of increasing the temperature difference between water and glass cover in the first effect and utilizes the latent heat of water vapor condensing on the glass of the first effect to produce more fresh water in the second effect. The performance of the regenerative still is evaluated by comparison with the performance of the conventional still under the same weather conditions. The results of the simulations show that the productivity of the regenerative still is 20% higher compared to the conventional still. Making the stills perfectly insulated increases their productivity two and one half folds. Insulation has higher effect on the regenerative still compared to the conventional still. The wind speed has a significant effect on the productivity of the stills; it can increase the productivity by more than 50% if the wind speed is increased from 0 to 10 m/s. The thickness of water on top of the first glass cover and the mass flow rate of water going into the second effect have marginal effect on the productivity of the regenerative still.

Keywords: Conventional solar still; Regenerative; Desalination; Double glass cooling

1. Introduction

Solar distillation is one of the thermal desalination methods that attracted researchers' attention due to its potential application in remote locations far from electricity grid. The simple solar

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Nomenclature

English Letters

A	absorptance (with indices for different surfaces)
C	specific heat
h	heat transfer coefficient except when used as h_{fg} (enthalpy of vaporization)
I	solar flux
m	mass
$\dot{m}$	mass flow rate
P	pressure
q	heat flux
T	temperature
t	time
x	distance along the glass cover
V	velocity
U	overall heat transfer coefficient

Greeks

α	absorptivity
δ	thickness
ε	emissivity
ρ	reflectivity
σ	Stefan–Boltzmann constant

Subscripts

a	ambient
b	basin
c	convective except when used with m in which case it indicates condensate
evp	evaporation
g	glass (g1, g2 first and second glass covers)
in	inlet
p	at constant pressure
r	radiative
w	water
wf	water film

still (henceforth conventional) consisting of a water basin and a single glass cover is the first proposed design of solar still that is easy to construct and has virtually no operating cost. However, even in areas of relatively high levels of solar insolation its annual performance per square meter of aperture is limited to an average of about 3 l/day. This motivated the search for methods to enhance the still productivity. These methods fall into two separate categories: active and passive. Among the active methods used is cooling of the glass cover and/or utilizing the latent heat of condensation dissipated through the glass cover. The glass cover gains heat from