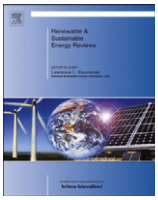
Renewable and Sustainable Energy Reviews 20 (2013) 322–335

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser



Wick type solar stills: A review

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ARTICLE INFO

Article history:
Received 19 March 2012
Received in revised form
16 November 2012
Accepted 19 November 2012
Available online 7 January 2013

Keywords:
Wick-type solar
Review
Passive solar distillation

ABSTRACT

Solar distillation is one of the water purification techniques that produce ultrapure water which is superior to most of the commercial bottled water sources. Though solar distillation is a simple method, productivity seems to be low due to the large thermal capacity and consumption of time. Researchers have taken efforts to make different designs of solar still for higher distillate yield and inferred that wick-type solar stills are effective and efficient. In this review, we are making an attempt to study the present status of different designs of wick type solar stills.

Contents

1. Introduction

People prefer technologies whenever they find something lacking in their life. Solar distillation is one such technology, which they found useful as a solution for their drinking water shortages. Though the availability of global water reserves is about 1.4 billion km^3, the sea water constitutes about 97.5%. Only the remaining 2.5% is gifted as fresh water for human beings and other living organisms. The available amount of fresh water in the

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http://dx.doi.org/10.1016/j.rser.2012.11.046

Nomenclature

ΔY	thickness of water layer, (m)
ρw	density of water, (kg/m^3)
c_{pw}, c_w	specific heat capacity of water (J/kg K)
$\Delta\tau$	time interval selected (2 min), (m/s)
U_2	overall heat transfer coefficient between bottom wall and surrounding (W/m^2 °C)
A_s, A	area of the still (m)
A_m	Area of the mirror (m^2)
m_i	hourly productivity (l)
P_d	daily productivity (l/m^2 day)
kw	thermal conductivity of water (w/m K)
h_1	total heat transfer from water to glass cover (W/m^2 °C)
h_2	heat transfer from floating-water to ambient (W/m^2 °C)
h'_2	heat transfer coefficient from glass cover to flowing water (W/m^2 °C)
T_g, T_w, T_a	glass, water and ambient temperatures (°C)
$\overline{T}_g$	average water temperature (°C)
$\overline{T}_g$	average glass temperature (°C)
T_{w1}	temperature of the flowing water over the glass cover (°C)
m_w	mass flow rate of water over the glass cover (kg/s)
τ	fraction of energy absorbed by water in still
L, l	latent heat of evaporation (J/kg °C)
$\in_\omega$	emissivity of water surface
σ	Stefan–Boltzmann constant, 5.669×10^{-8} (w/m^2 °C^4)
m_{ew}	amount of water distillate per unit time per unit basin area (kg/m^2 s)
q_u	the rate of heat loss due to water flow
P_w, P_g	saturated vapour pressure of water and glass (N/m^2)
h_{rw}, h_{ew}, h_{cw}	radiative, evaporative and convective heat transfer coefficient (W/m^2 °C)
η_o	overall efficiency of the distillate output
α_g	absorptance-transmittance product of glass cover
b_3, b_3, b_1	breadth of the glass cover, tilted, floating-wick surfaces (m)
dx_3, dx_2, dx_1	length of the glass cover, tilted, floating-wick surfaces (m)
h_1	total heat transfer coefficient from tilted-wick surface to glass (W/m^2 °C)
h_2	total heat transfer coefficient from floating-wick surface to glass (W/m^2 °C)
h_3	total heat transfer from glass surface to ambient (W/m^2)
T_g, T_{w1}, T_{wf}	temperature of glass, tilted, floating-wick, ambient (°C)
α_{w1}	absorptivity of blackened tilted-wick surface
m_{w1}	mass flow rate along the tilted-wick along the length L_1 (kg/s)
$\overline{T}_g$,$\overline{T}_{w1}$,$\overline{T}_{wf}$	average temperature of the glass, tilted and floating-wick surfaces (°C)
L_1, L_2	length of the tilted and floating-wick stills (m)
h_4	convective and radiative heat transfer coefficient from flowing water to ambient (W/m^2)
θ_{evap}	evaporative heat transfer from flowing water to the ambient (W/m^2)
m_{fw}	mass of the flowing water over the glass cover (kg/s)
T_{fw}	temperature of the flowing water over the glass cover (°C)
A_{wf}, A_{w1}	area of floating and tilted-wick surfaces (m$_2$)
h_{ewfa}	evaporative heat transfer coefficient form floating-wick to ambient (W/m^2)
$Q_{sun,re}$, $Q_{sun,re}$, $Q_{sun,df}$	rate of absorption of reflected, direct and diffused solar radiation (W)
G_{dr}, G_{df}	direct and diffused solar radiation on a horizontal surface (W/m^2)
$Q_{sun,g}$, $Q_{sun,w}$	absorption of solar radiation on glass and wick surfaces (W/m^2)
τ_g	transmittance of glass cover
β	incident angle of sunrays to glass cover (°)
β'	incident angle of reflected sunrays to glass cover (°)
ρ_m	reflectance of reflector
α_w	absorptance of the wick
w	width (m)
m_{cp}	heat capacity (J/K)
l_s	length of the still (m)
Q_{ci}, Q_{ei}, Q_{ri}	convective, evaporative and radiative heat transfer from water to glass cover (W/m^2)
h_{ci}, h_{ri}	convective and radiative heat transfer coefficient from glass cover to ambient (W/m^2)
Si	computation ratio (heat of evaporation to total heat transferred)
Q_{ac}	heat transferred from ambient to glass cover (W/m^2)
Q_{be}	conduction heat transfer through base (W/m^2)
h_{ca}	heat transferred from glass cover to atmosphere by convection (W/m^2)
h_θ	latent heat (kJ/kg)
H_s, $I(t)$, S	incident solar radiation on glass cover per unit area per unit time (W/m^2)
M	mass of the water (kg)

form of rivers, lakes, surface water, polar ice, ground water etc., cannot match the water requirement for the entire globe. Hence solar distillation can be considered as a practical alternative for the production of drinking water.

2. Working of a wick type solar still

The solar radiation falling on the glass cover transmits through it and reaches the wick surface, where it is absorbed. A part of the energy is utilized for heating the water flowing through the wick due to capillary action. A large amount of heat gets trapped inside the still, and transfer of energy takes place from the wick surface to the glass cover and to the ambient air. Heat transfers in the distillation system are governed by external and internal modes. The external heat transfer mode occurs due to convection and radiation, which are independent of each other and occurs outside the still. Heat transfer within the solar distillation unit is referred to as the internal heat transfer mode, which occurs due to radiation, convection and evaporation. In internal heat transfer mode, the mass transfer accompanied with radiative and convective heat transfer. Water flowing through the wick surface gets heated and evaporated into vapors. The saturated water vapour condenses in the lower surface of the glass cover after releasing the latent heat of vaporization. The condensed water droplets trickle down due to gravity and get collected in the drainage channel.