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# Thermal performance of a single basin solar still with PCM as a storage medium

A.A. El-Sebaii [1],*, A.A. Al-Ghamdi, F.S. Al-Hazmi, Adel S. Faidah

*Physics Department, Science College, King Abdul Aziz University, P.O. Box 80203, Jeddah 21589, Saudi Arabia*

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ABSTRACT

Transient mathematical models are presented for a single slope-single basin solar still with and without phase change material (PCM) under the basin liner of the still. Analytical expressions for temperatures of the still elements and the PCM have been obtained. The still performance has been investigated by computer simulation. Numerical calculations have been carried out, using stearic acid as a PCM, on typical summer and winter days in Jeddah (lat. 21° 42′ N, long. 39° 11′ E), Saudi Arabia. Effect of mass of the PCM ($m_{pcm}$) on the daylight $P_{dl}$, overnight $P_{on}$ and daily productivity $P_d$ and efficiency $\eta_d$ of the still for different masses of basin water $m_w$ has been investigated. It is found that $P_{dl}$ decreases as $m_{pcm}$ increases; but $P_{on}$ and $P_d$ increase significantly with an increase of $m_{pcm}$ due to the increased amount of the heat stored within the PCM. During discharging of the PCM, the convective heat transfer coefficient from the basin liner to basin water is doubled; thus, the evaporative heat transfer coefficient is increased by 27% on using 3.3 cm of stearic acid beneath the basin liner. Therefore, on a summer day, a value of $P_d$ of 9.005 (kg/m$^2$ day) with a daily efficiency of 85.3% has been obtained compared to 4.998 (kg/m$^2$ day) when the still is used without the PCM. The PCM is more effective for lower masses of basin water on winter season.



## 1. Introduction

There is an urgent need for clean, pure drinking water in many countries. Often, water sources are brackish and/or containing harmful bacteria and therefore can not be used for drinking. In addition, there are many coastal locations where sea water is abundant but potable water is not available. Pure water is also needed in some industries, hospitals and schools. Solar distillation is one of many processes that can be used for water purification. Solar radiation can be the source of heat energy where brackish or sea water is evaporated and is then condensed as pure water.

Solar stills are broadly divided into passive and active stills. Passive stills are further divided into basin and inclined types. Extensive research was reported on different methods to improve the productivity of these stills [1–10]. The important parameters affecting the performance of a solar still, such as solar intensity and the mass of basin water [11] as well as wind speed [12], are also reported. Still performance was found to increase with thinner water films [11]. However, decreasing the thickness of basin water results in a decrease of overnight productivity of the still [13]. Therefore, to improve the still productivity even with thicker water layers (deep basins), a baffle plate made of mica was inserted within the basin water [14]. It has been found that, the baffle plate significantly enhances the single-basin solar still performance all year round [15]. Furthermore, solar stills suffer from their low productivity due to loss of heat of condensation to surroundings via the glass cover. This problem has been solved by utilizing this heat to heat brine in multi-effect stills [16]. However, no work has been done to make use of the heat dissipated from the bottom of the still, except by insulating the bottom, which does not prevent heat seepage [17]. Another method that may be used to improve the productivity of solar stills is by using storage systems either sensible or latent heat systems. This method utilizes the heat dissipated from the bottom of the still. The latent heat thermal energy storage systems have many advantages over sensible heat storage systems including a large energy storage capacity per unit volume and almost constant temperature for charging and discharging [18]. Recently, many papers have appeared concerning the use of PCM as storage media integrated with some solar-thermal energy systems; such as solar cookers [19,20], domestic hot water systems [21] and greenhouses [22] in order to compensate for a temporal mismatch of supply and demand of solar energy. With a thin layer of PCM under the basin liner of a solar still, a considerable amount of heat will be stored within the PCM during sunshine hours instead of wasting it to surroundings. During solidification of the PCM, the stored heat discharges to keep the basin water at a temperature enough to produce fresh water during the night even with thin layers of basin water. This causes an enhancement of the still

* Corresponding author. Tel.: +966 505604537; fax: +966 26951106.
*E-mail address:* aasebaii@yahoo.com (A.A. El-Sebaii).
[1] Permanent Address: Physics Department, Faculty of Science, Tanta University, Tanta, Egypt.

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