Mathematical analysis of solar still with storage : A review

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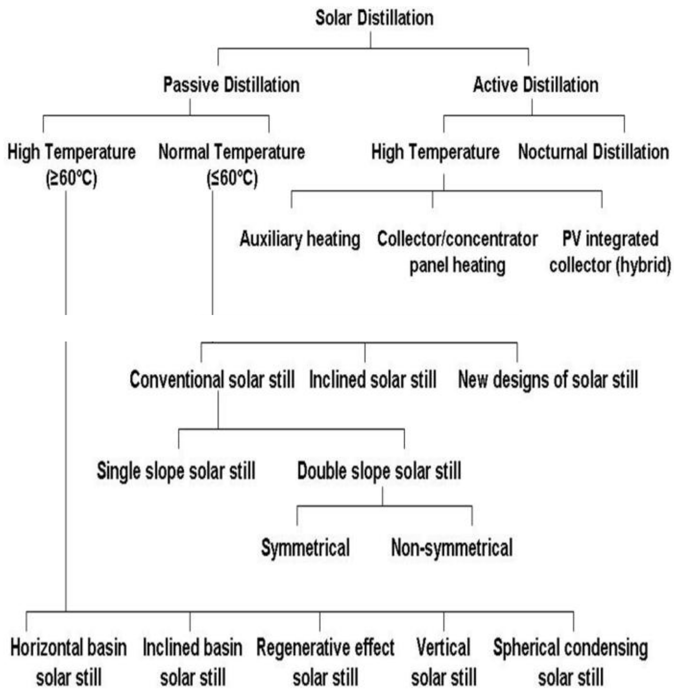
Abstract - *Transient mathematical models are considered for a single slope single basin solar still with and without phase change materials under the basin liner of the still. Analytical expression for heat balance equation will be obtained. The still performance has to be investigated by computer simulation. The various equations of heat balance are found out on Glass surface, Water mass, Basin lines and Storage. The storage stores the heat in the form of latent heat and deliver these heat in the night period. The efficiency of storage is calculated and performance of still is found out for a single day.*

Key Words**:** ***Solar still, storage, solar radiation.***

1. INTRODUCTION

There is an urgent need for clean, pure drinking water in many countries. Often, water sources are brackish and containing harmful bacteria and therefore cannot 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 method to improve the productivity of these stills. The important parameters affecting the performance of solar still, such as solar intensity and the mass of basin water as well as wind speed are also reported .still performance was found to increase with thinner water films. However, decreasing the thickness of basin water result in a decrease of overnight productivity of the still. Therefore, to improve the still productivity even with thicker water layers, a baffle plate made of mica was inserted within a basin water. It has been found that, the baffle plate significantly enhances the single basin solar still performance all year.



The various equations of heat balance are found out on Glass surface, Water mass, Basin lines and storage By analyzing these equations we get temperatures at that point and it is helpful to determine the performance of solar still.

2. REVIEW OF WORK CARRIED OUT

A.A. Al-Sebaii: A single basin solar still has en investigated by computer simulation under Jeddah(Saudi Arabia) weather condition. A thin layer of steric acid as a PCM has been integrated beneath the basin liner to enhance the overnight productivity of the still. And it is compare with still without PCM.

The daylight productivity is found to decrease slightly with increasing the mass of PCM but overnight and daily productivity are significantly increasing with increasing mass.

The PCM becomes more effective at lower masses of basin water during the winter. Therefore, it is recommended to integrate storage materials in active and wick type solar still to produce fresh water overnight.

P.I. Cooper determines the maximum efficiency of single effect solar stills, the overall efficiency of a solar still is determined by the product of an efficiency of absorption or retention of radiation and an efficiency of utilization of this absorbed energy.

An ideal still has been proposed and a set of curves presented which illustrate the maximum theoretical productivities which could be expected linear relationship has been derived which indicate that the maximum attainable ideal efficiency over a day's operation will rarely exceed 60 percent.

A small solar still was constructed which embodies the futures required to attain high efficiencies. The measured efficiency rarely exceeds 50 percent. For a practical solar still installation it appears that the ultimate efficiency during times of high solar radiation intensity and ambient temperatures is restricted to about 50 percent.

Prof. Alpesh Mehta: worked on Design of solar distillation system and concluded we can conclude that the increase in temperature and hence the evaporation is maximum in the period of 11:15 am to 1:30 pm. The maximum temperature achieved is 530c which is at 1:30 pm. then the temperature decreases. The aim of our experiment was to get pure water from the brackish water available. The brackish water we have supplied was 14 liters and at the end of the experiment we got 1.5 liters. The experiment was carried out in winter season. The TDS level of purified water obtained is 81 PPM. So the water obtained is potable. Theoretically, the experiment should fetch out 2.33 liters. So the efficiency of the system is 6%.

Abdullah M. Al Shabibi and M. Tahat: This paper investigates the thermal performance of solar water still with enhanced solar heating system. A number of variables have been considered including the water depth inside the still and the inlet saline water temperature to the solar still from the pre-heater solar collector system. It was found that 1 cm depth gives the best performance in terms of fresh water yield and thermal efficiency. The addition of the solar water pre-heater to the system has significantly increased the inlet basin saline water temperature to almost saturated temperature and saline water in the basin needed only small heat to be vaporized and hence increases the production of fresh water and enhances the solar still thermal efficiency. Three types of still basin bottom surface were tested: flat, finned and corrugated. The finned surface was found to give the best performance. Using finned surface can increase the fresh water production by 20%. The effect of using a solar heating system was also investigated and found to enhance the still performance significantly.

3. METHODOLOGY

The simple solar still worked only in day period therefore the storage is provided for the all day performance of the still. Generally the storage is PCM material. The various equation of heat balance at different parts of the solar still are made for the evaluating the temperature at that point. Efficiency of still is to be calculated using various formulas. Equations are given below

1) GLASS COVER

$$\alpha'_g I(t)+h_1(T_w-T_g) = h_2(T_g-T_a) \text{ or } h_{rg}(T_g-T_{sky})+h_{cg}(T_g-T_a)$$

Where,

$\alpha'_g = (1-R_g)\alpha_g$ and

$h_1=h_{cw}+h_{rw}+h_{ew}$

$h_2=h_{rg}+h_{cg}$

2) WATER MASS

$$\alpha'_w I(t)+h_3(T_b-T_w) = M_w Cp_w[dT_w/dt]+h_1(T_w-T_g)$$

where,

$\alpha'_w = (1-\alpha_g)(1-R_g)(1-R_w)\,\alpha_w$

$h_3=h_{cbw}$

$h_1= h_{cw}+h_{rw}+h_{ew}$

3) BASIN LINE

$$\alpha'_b I(t)=h_3(T_b-T_w)+h_4(T_b-T_s)$$

where,

$\alpha'_b = (1-\alpha_g)(1-R_g)(1-R_w)(1-\alpha_w)\alpha_b$

$h_4 = h_{cbs}$

$h_3 = h_{cbw}$

4) STORAGE

$h_4(T_b - T_s) = M_s Cp_s (dT_s/dt) + h_5(T_s - T_a)$

where,

$h_4 = h_{cbs}$

$h_5 = (k_b/x_{in})$

Nomenclature

α'_g	absorptivity of glass
I	solar radiation intensity(W/m^2)
T_w	temperature of water
T_g	temperature of glass
T_a	ambient temperature
T_{sky}	sky temperature
T_b	basin temperature
T_s	storage temperature
α'_w	absorptivity of water
α'_b	absorptivity of basin
C_{pw}	specific heat of water
C_{ps}	specific heat of stoage
h_{cw}	convective heat transfer coefficient of water
h_{rw}	radiative heat transfer coefficient of water
h_{ew}	evaporative heat transfer coefficient of water
h_{rg}	radiative heat transfer coefficient of glass
h_{cg}	convective heat transfer coefficient of glass
m_w	water mass
m_s	mass of storage

4. CONCLUSION

From the literature cited it is observed that the experimental maximized efficiency of solar still is around 60 percent. Thus the efficiency of solar still with storage is to be calculating by mathematical modeling. It can also be helpful for the performance analysis of solar still for day-night period.

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