EXPERIMENTAL STUDY ON A STEPPED BASIN SOLAR STILL

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ABSTRACT

In the present work an attempt has been made to improve the productivity of a single slope solar still by constructing many steps to the basin of the solar still. Experimental setup was fabricated and observations were taken in the premises of SHIATS Allahabad, U.P., INDIA. It is observed that productivity can be reached up to more than 6 liters per day for 1 metre square area of the basin when multi-wicks are added to the system. Overall increase in the production of stepped basin solar still using wick type arrangement in the basin is 20.5% more than without using wick arrangement

Key words: Stepped basin solar still, Solar distillation and Solar intensity.


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1. INTRODUCTION

Solar distillation is the process of producing potable water from the brackish water. Since it requires simple technology, it is of low maintenance and can be used anywhere without environmental pollution. Main problem with this type of system is the low productivity per unit installation area compared to fuel base desalination method. Increasing the productivity of the solar still has therefore been the focus of many researchers. Number of attempts have been made by many researchers to improve the absorbptivity of the basin liner by using different heat absorbers such as gravel [1], sponge cubes [2], rubber [3], charcoal [4, 5], dyes and ink [6, 7]. Many researchers experimented with solar still that are coupled to reflectors [8, 9], flat plate collectors. Velmurugan et al. experimented on fin-type passive solar still and found that the yield was increased by 52%. Productivity of the solar still increases with increase in absorber area [10]. Kalidasa Murugvel [11] have used wick materials to spread the water throughout the basin of a passive double slope solar still to enhance
the productivity the still. Rai et al [14, 15] have used latent heat storage materials in the basin liner to enhance nocturnal output.

In the present work an attempt has been made to improve the productivity of the solar still by making stepped basin. Performance is further increased by adding wick to the basin.

2. EXPERIMENTAL SETUP
The experimental setup consists of a passive solar distillation unit with a glazing glass cover inclined at 26°. Since the geographical location Allahabad lays 26° in northern hemisphere thus it is justified to take inclination for glass cover to receive maximum insolation. This tilted glass cover of 3 mm thickness, served as solar energy transmitter as well as a condensing surface for the vapour generated in the basin. Basin having area 1.00 m × 1.00 m is made up of Galvanized Iron has an effective area of 1.00 m². This solar still consist of stepped base construction having 8 trays of 100 × 12 × 2 cm³ each, placed in the basin of solar still. Trays are blackened, for having maximum possible absorption of solar energy. The basin of the distiller was blackened to increase the solar energy absorption. For the better performance of stepped-type solar still wick material is added on side absorber of the basin. A distillate channel was provided at end of the basin. For the collection of distillate output, a hole was drilled in the channel and plastic pipe was fixed through it with an adhesive (Araldite). An inlet pipe and outlet pipe were provided at the top of the side wall of the still and at the bottom of the basin tray for feeding saline water into the basin and draining water from still for cleaning purpose, respectively. Rubber gasket was fixed all along the edges of the still. All these arrangements are made to make the still air tight. Water gets evaporated and condensed on the inner surface of glass cover. It runs down the lower edge of the glass cover. The distillate was collected in a bottle and then measured by a graduated cylinder.

Thermocouples were located in different places of the still. They record different temperature, such as glass cover and water temperature in the basin and ambient temperature. In order to study the effect of salinity of the water locally available salts were used at various salinities. All experimental data are used to obtained the internal heat mass transfer coefficient for single slope still.

![Photographic view of stepped basin solar still](image1.jpg)

Figure 1 Photographic view of stepped basin solar still
2.1. Productivity and efficiency of the still

The hourly productivity \( P_h \) is calculated using the following equation [12]

\[
P_h = h_{ewg}(T_w - T_g) \times 3600/L_w
\]

(1)

The daily productivity \( P_d \) as well as the daily efficiency without and with wick are calculated using the following formulas

\[
\eta_d = \frac{P_d}{A_s \Sigma I} \times 100(\%)
\]

(2)

\[
\eta_d = \frac{P_d}{A_s \Sigma I} \times 100(\%)
\]

(3)

Where \( \Sigma I \) is the daily average of the latent heat of vaporisation of water and \( \Delta t \) is the time interval during which the solar radiation is measured.

Exergy efficiency of the system can be calculated by using the following expressions [13]

\[
\eta_{ex} = \frac{Ex_{output}}{Ex_{evap}}
\]

(4)

\[
Ex_{output} = Ex_{evap} = \frac{mewL}{3600 \text{ s.h}^{-1}} \times \left( 1 - \frac{T_a+273}{T_w+273} \right)
\]

(5)

Where \( m \) is hourly yield of solar still (kg/h), \( L \) is the latent heat of vaporization (J/kg), \( T_a \) is the ambient temperature (°C) and \( T_w \) is the water temperature (°C).

\[
Ex_{output} = Ex_{evap} = \frac{mewL}{3600 \text{ s.h}^{-1}} \times \left( 1 - \frac{T_a+273}{T_w+273} \right)
\]

(6)

Where \( Ex_{sun} \) (solar still) is the exergy input to the solar still through radiation and can be obtained from the following equation

\[
Ex_{sun} (\text{solar still}) = A_s \times I(t_s) \times \left[ 1 - \frac{4}{3} \times \left( \frac{T_a+273}{T_s+273} \right) + \frac{1}{3} \times \left( \frac{T_a+273}{T_s} \right)^4 \right]
\]

(7)

Where \( A_s \) is the area of basin in solar still (m²). \( I(t_s) \) is the solar radiation on the inclined glass surface of solar still (W/m²) and \( T_s \) is the sun temperature, 6000 K.

3. RESULTS AND DISCUSSIONS

Figure 2 shows variation in solar intensity with respect to time of the day experiments were carried out of several days in the month of may and june with and without wick in the stepped basin. Variation of solar intensity in Figure 2 with the time of the day in the month of may with and without wick. The value of maximum intensity reaches 1200 W/m² at around 12 o’clock for the day when wicks are used in the stepped basin. Whereas maximum intensity of 1000 W/m² reaches around 1 o’clock on the day when stepped basin was used without multi-wick.

Figure 3 shows variation of wind velocity with respect to time of the day with and without multi-wick arrangement.
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**Figure 2** Variation of the Solar Intensity with time of the Day

**Figure 3** Variation of Wind Velocity with time of the Day

**Figure 4** Variation of Temperature with Time of the Day
Figure 4 shows variation of temperature of different component of solar still with respect to the time of the day. Water temperature without wick is more than the water temperature with wick in spite of the fact that the solar intensity is more on the day when wicks were attached to the basin. This due to the fact that due to addition of wicks to the basin, rate of evaporation increases, which causes the temperature of the water to decrease. Glass temperature with wick is more due to high solar intensity on the day.

Figure 5 shows the variation of productivity with respect to time of the day. For two different cases (1) basin with wick (2) basin without wick. It is observed that productivity with multi-wick arrangement is higher than without wick arrangement. Use of wick to the basin increases day time productivity by 14 %. Night time productivity of distil water using wick to the basin increases by 50.5 % than without using wick. It is due to thermal inertial effect of the wick material. Overall increase in the production of stepped basin solar still using wick type arrangement 20.5 % than without using wick arrangement.

4. CONCLUSION
A single-slope solar still is fabricated with stepped basin and its performance is measured in the Allahabad climatic conditions of U.P India. Energy efficiency 60% is obtained for stepped basin solar still, which is further increases 64.7 % when multi wicks are added to the basin. Exergy efficiency of the system is calculated as 10.7 % for without wick and 10.2 % for multi-wick arrangement.

REFERENCES


