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PRODUCTIVITY ENHANCEMENT IN SINGLE SLOPE SINGLE BASIN SOLAR STILLS: A COMPARATIVE STUDY

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ABSTRACT

The productivity of traditional single slope single basin star still was compared with single slope furrowed basin star still underneath totally different climatical condition for brakish water chemical change. star still of the each were fictional as per the quality dimensions. the total setup is mounted at the latitude of the operating atmosphere (i.e.,Trichirapalli Latitude ten.80°N) is that the distinctive feature of this experimental setup. The conventional single slope single basin star still unconcealed best results compared to single slope furrowed basin star still at terribly low price and it are often utilized in all areas.

Keywords: single basin solar still, cost, productivity, remote areas

1. INTRODUCTION

Water is one among the five elements of the world.. Due to increases in population , day by day the scarcity of pure water increases. In our Earth ,consist one fourth of its area as land remaining three part is water. The water present in the is of saline in nature. So the form which is available is not suitable for human need. Now a days water pollution creates big impacts in human life. The brackish (or) polluted water is the main origin for many dieses. Millions of Childs are dead and millions of peoples are affected due to polluted water.

There are several concepts are available to produce the fresh water. Desalination is the one of promising method of producing potable water from brackish or sea water. This process is done by giving high amount of energy to the desalination still. Due to increasing cost of the fuel ,the solar energy is one of the effective and costless energy which can be used as a source of energy.

Several methods have been developed in this desalination technique. The methods available are single slope solar still, double slope solar still with single basin and multi basin solar still. It is one of the simplest devices which is used to produce fresh water.Here we are going to deal with the Single slope stills of different forms.The main advantage of single slope single basin solar still has more thermal conductivity to compare with double slope solar still. And also the fabrication of this still is done by easily from locally available material. (Vasanthy and Jeganathan 2007, Vasanthy et.al., 2008, Raajasubramanian et.al., 2011, Jeganathan et.al., 2012, 2014, Sridhar et.al., 2012, Gunaselvi et.al., 2014, Premalatha et.al., 2015, Seshadri et.al., 2015, Shakila et.al., 2015, Ashok et.al., 2016, Satheesh Kumar et.al., 2016).

ISSN:0975-3583,0976-2833 VOL7,ISSUE04, 2016

2. MAIN OBJECTIVE OF THE PAPER

The main objective of this paper is to increase yield of the fresh water economically. To get this we compare the output of single slope corrugated basin and normal single slope single basin solar still. The corrugated basin fabricated by stainless steel. The main advantage of corrugation is to increase the area of the basin by the way we can increase the evaporation rate by setting the still at 11^0 inclinations.

The objectives of the present study was to set the basin water at 11° inclination by this we can improve the evaporation of basin water, increasing the inlet basin water temperature, increasing the inner area of the basin without changing the outer area of the basin, theoretical and experimental study on the single slope single corrugated basin and comparison of results between the theoretical and experimental yield and comparing the yield of the both setup namely single slope single corrugated basin and normal single slope single basin solar still. (Manikandan et.al., 2016, Sethuraman et.al., 2016, Senthil Thambi et.al., 2016).

Methodology

Experimental setup and observations

A simple desalination unit consist of wood or composite material which is having good insulation property, basin, and transparent glass. The wood is used to fabricate the outer shell of still. And the basin is used to keep the brackish water. Also the basin is colour with Black which is used to absorb the sun rays. Then finally the transparent glass is used to cover the still which is used to condense the evaporated water. In between the basin and the outer shell the insulating material set to avoid the thermal energy loss.

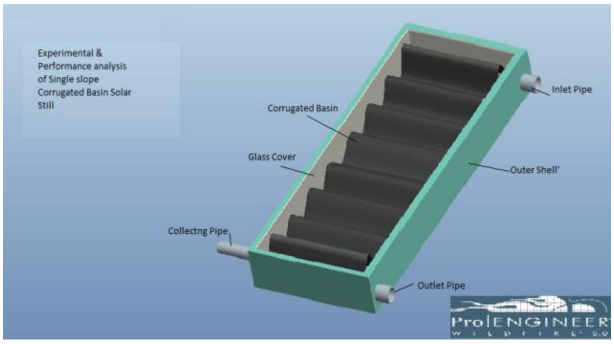

Fig1.Diagram of single slope single corrugated basin.

The normal single basin single slope solar still is having normal basin which is placed in parallel to the surface. The normal still only the glass cover is set at11° inclination. Here we have fabricated the normal single slope single basin to have the dimensions of 51cm*95cm .

But the corrugated still is having wooden outer shell, transparent glass cover and the corrugated basin which is used to maintain the brackish water in 11° inclination. Here we can set the total setup in the inclination angle of local atmosphere. The dimension of the present experimental setup is 51cm×95cm in outer basin and 51cm×110cm in inner basin, the outer covering glass of size 56cm×108cm and the length of the outer shell is 110cm and breath is 58cm and the thickness is 12cm, also here we can use 2mm Thermocol insulation is used between the basin and outer shell for both normal single slope single basin solar still and

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corrugated basin solar still.

The increases of inner area of the basin increase the evaporation rate of the saline water. Also the basin inclination is to increase the sunrays absorption.

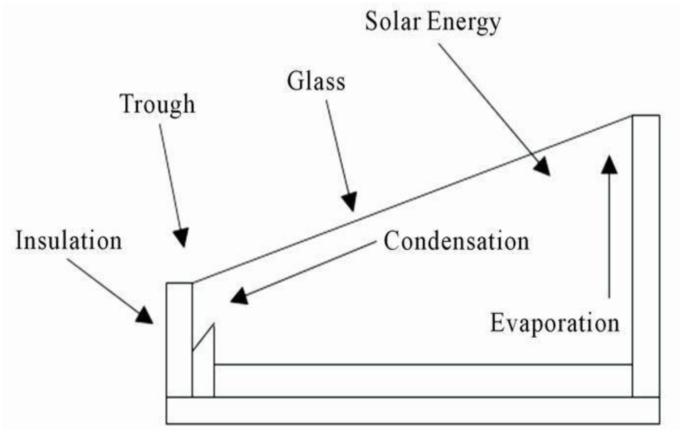

Fig 2.Model diagram for simple single slope single basin solar still

3. THERMAL MODELLING

A. Energy balance equations for modelling single slope solar still:

The following assumptions were taken into consideration for writing energy balance equations for different components of a single slope active solar still derived by G.N.Twari et.al [2].

1. Thermal capacity of glass cover and insulating material of wall of solar still has been neglected.
2. There is no temperature gradient in the water inside the basin.
3. The system is under quasi-steady state condition.
4. The connecting pipe between the solar still and storage water tank are perfectly insulated.

Energy balances on condensing cover:

The energy balances for inner and outer surfaces of condensing cover are as follows

Inner condensing cover

$$\alpha'_g I + \hbar_t (T_w - T_{ci}) - U(T_{ci}) = \frac{K_g}{L_g}(T_{ci} - T_{co}) \ldots\ldots (1)$$

Outer condensing cover

$$\hbar_a (T_{co} - T_a) = \frac{K_g}{L_g}(T_{ci} - T_{co}) \ldots\ldots (2)$$

Where,

$$\hbar_t = \hbar_{cw} + \hbar_{ew} + \hbar_{rw} \ldots\ldots (2a)$$

Energy balance for water mass:

The energy balance for basin water is

$(M)\frac{dT_w}{dt} = (I)\alpha'_W + 2U_{bw}(T_b - T_w) - \hbar_t(T_W - T_{ci})$ ……. **(3)**

With the help of above equations [1–3], one can get the following first order differential equation as,

$$\frac{dT_w}{dt} + aT_w = f(t) \text{...... } \mathbf{(4)}$$

Where,

$a = 1/(M)\_w\ [[(2U\_bwU\_ba)/(U\_bw + U\_ba\ )] + ((p - A\_1\ )\ \hbar\_t)/P]$ ……. $(4a)$

$$f(t) = \frac{1}{(M)_w}\left[\left[\alpha'_W + \frac{\alpha'_b U_{bw}}{U_{bw} + U_{ba}}\right] + (I) + \frac{(\hbar_t A_1 + \hbar_t B_1)}{P} + \left(\frac{2U_{bw}U_{ba}}{U_{bw} + U_{ba}}T_a\right)\right] \text{.....} (4b)$$

In order to obtain an approximate solution of Eq. ***(4)*** *the following assumptions have been made:*

1. The time interval Δt (0<t<Δt) is small.
2. The function f (t) is constant, i.e. $f(t) = \underline{f(t)}$ for the time interval Δt, and 'a' is constant during the time interval Δt.
3. The internal convective (h_{cw}), evaporative (h_{ew}) and radiative (h_{rw}) heat transfer coefficients for east and west condensing cover have been evaluated at initial (t=0) water (T_{w0}) and inner condensing cover (T_{ci0}) temperature and assumed tobe constant over 0-t time interval. Hence, h_{te} and h_{tw} have been considered constant over 0-t time interval.

After making the above assumptions, Eq. **(4)** becomes first order simple differential equation. The solution of Eq**. (4)** with initial condition, Tw = Tw_0 at t=0, becomes

$$T_w = \frac{\underline{\underline{f(t)}}}{a}[1 - exp(-a\Delta t)] + T_{w0}\ exp\ exp(-a\Delta t) \text{.....} (5)$$

And inner and outer glass cover temperatures obtained from Eqs. **(1) – (3)** are:

$$T_{ci} = \frac{(A_1 + T_W)}{p} \text{...... } \mathbf{(6)}$$

$$T_{co} = \frac{\frac{K_g}{L_g}T_{ci} + \hbar_a T_a}{\frac{K_g}{L_g} + \hbar_a} \text{...} (7)$$

The obtained values of water and inner condensing cover temperature become initial temperature for next set of calculations. Similarly this procedure has been adopted for other set of time interval.

ISSN:0975-3583,0976-2833 VOL7,ISSUE04, 2016

The constants of Eqs. (7) And (8) are given in the appendix. The evaporative heat transfer rate of a single slope solar still is given by

$$q_{ew} \doteq \hbar_{ew}(T_w - T_{ci}) \ldots \ldots (8)$$

Then the hourly yield can be found as

$$\dot{m} = \frac{\dot{q}_{ew} \times 3600}{L} \ldots\ldots \quad \textbf{(9)}$$

Table 1: Design Parameters used in Thermal Modelling

Parameters	**Value**
Design parameters for solar still	
α_b	0.8
α_g	0.05
α_w	0.6
ε_w	0.95
Eg	0.95
A_s	0.561 m^2
L_b	0.005 m
L_g	0.004 m
K_b	0.035 W/m°C
K_g M	0.78 0 W/m°C 20 kg
Σ	5.67×10^{-8} W/m^2 °C

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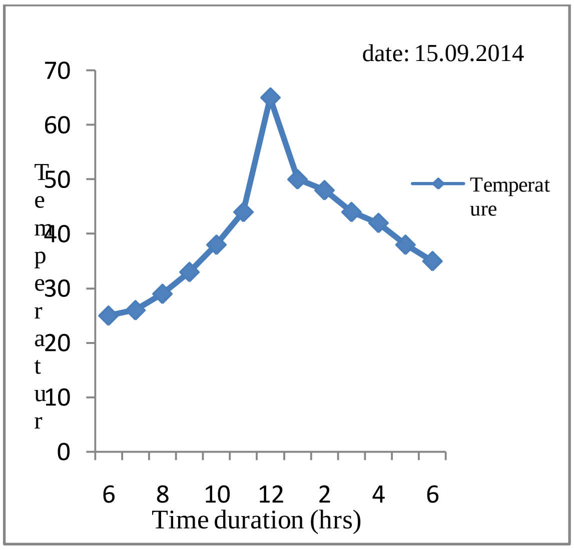

Figure 3: Hourly variation of basin water temperature for a day of experiment in corrugated basin

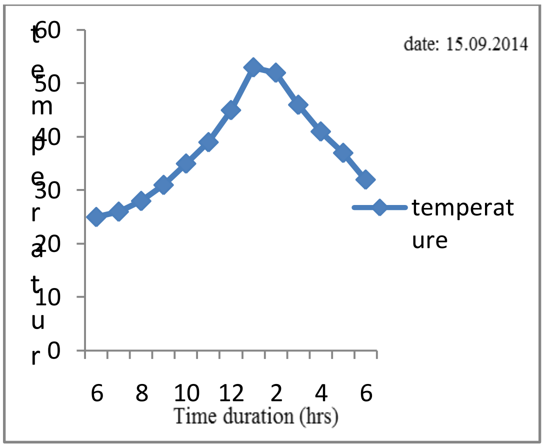

Figure 4 :Hourly variation of basin water temperature for a day of experiment in normal basin

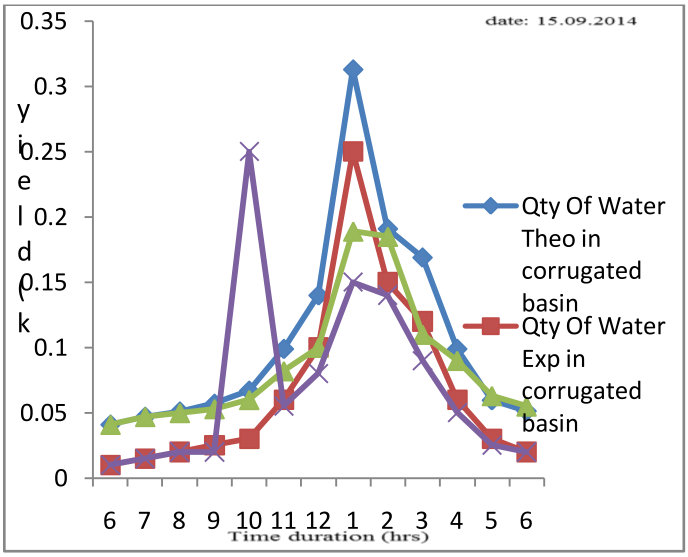

Figure 5 : Hourly variations of Experimental & Theoretical Yield.in single slope solar still

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4. EXPERIMENTAL UNCERTAINTY

A solarimeter, thermocouples, an anemometer and a measuring jar were used to measure the intensity of the solar radiation, the temperatures at various locations, the wind velocity and the distillate output, respectively.

The experiments have been conducted at the open terrace of a residential plot at Crawford Tiruchirappalli, a city in southern India during November, 2014. The observations are taken for12 h duration starting from 6 A.M to 6 P.M. The amount of water produced, Basin temperature, Inner Condensing temperature was calculated using Euro Lab Digital Multi Thermocouple for every 1 hrs.

5. RESULTS AND DISCUSSION

The theoretical model for the current experimental setup i.e. Single slope solar still usingwith corrugated basin has been developed from G.N.Tiwari et.al [1].The output of the setup which is the quantity of water for an hour is found to be the amount of water collected from condensing cover.The graphical representation of variation of temperature with time and comparative graph on theoretical and experimental data shown in fig 3to 5.

6. CONCLUSION

The climatic, design parameters and heat transfer coefficient, the hourly variation of water, inner and outer condensing cover temperature are used and hourly yield have been evaluated theoretically and compared with the experimental results. The ultimate result of this paper shows that the normal single basin single slope solar still is gives less productivity to compare with the single slope single corrugated basin (i.e. the active solar still yield is 35% higher). The comparative study reveals that the single slope single corrugated basin solar still under natural circulation mode gives higher productivity.

Glossary

A_s : Surface area of condensing cover (m^2)

h_t : Total internal heat transfer coefficient ($W/m^2°C$)

h_{cw}:Internal convective heat transfer coefficient ($W/m^2°C$)

h_{ew} : Internal evaporative heat transfer coefficient ($W/m^2°C$)

h_{rw}:Internal Radiative heat transfer coefficient ($W/m^2°C$)

h_a: Heat transfer coefficient between outer condensing cover and ambient air ($W/m^2°C$)

I : Solar intensity on the condensing cover ($W/m^2°C$)

K_g : Thermal conductivity of condensing cover (W/m°C)

L_g: Thickness of condensing cover (m)

L : Latent heat of vaporization (J/kg)

M : Mass of water in the basin of solar still (kg) m : Hourly distillate yield (kg/m^2)

P : Partial saturated vapour pressure (N/m^2)

q_{ew}: Evaporate heat transfer rate (W/m^2)

T : Temperature (°C)

U_{EW}: Internal radiative heat transfer coefficient on condensing cover (W/m^2°C)

U_{bw}: Heat transfer coefficient between basin liner and water (W/m^2°C)

U_{ba}: Heat transfer coefficient between basin liner and ambient air (W/m^2°C)

U_a: Overall heat transfer coefficient between outer condensing cover and ambient air (W/m^2°C)

V : Air velocity (m/s)

Xi : Theoretical or predicted value

Yi : Experimental value

Subscripts

W : Water

Ci : Inner condensing cover

Co : Outer condensing cover

A : Ambient

b : Basin liner

Greek Letters

α_g': Fraction of solar energy absorbed by glass cover

α_b': Fraction of solar energy absorbed by basin water

ε_g : Emissivity of glass cover

ε_W : Emissivity of water

(ατ) : Effective absorptance – transmittance product

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