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Design and Experimental Analysis of Reflector to Improve the Efficiency of Double Slope Type Solar Still

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ABSTRACT: Clean potable water is a basic necessity for human being along with pure air and food. Nearly 97% of the available water in our planet is salty sea water. About 2% of the water exists in Polar Regions in frozen state; only 1% water is available for human consumption. Many desalination techniques are available to get fresh water. Solar distillation is one of the cheapest methods to solve this problem. Single basin solar stills are mainly used for this purpose. They may have either single slope cover or double slope cover. The productivity of the single basin solar stills is very low, many attempts were made to enhance the performance of single basin solar still, in this study we are going to use 60*60*40 mm single basin double slope solar still to improve the performance of the solar still. We are doing some internal modification and external modification. For internal modification we use wick material with fin apparatus for heat storage and for external modification we use top and bottom reflectors. With the implementation of taguchi method we use different parameter; from this the production rate is maximum for Day 8, square fin with black cotton of 1cm water level and reflector angle of 135° produced the peak level production of 750 and 800 ml/m²h respectively at 1 pm. Reflector was helpful in accelerating production rate during bright sunshine hours and heat storage material was effective in sustaining higher production rate during the declining sunshine hour.

KEYWORDS: Solar still, Desalination, Basin, Reflector, Fin Apparatus.

I. INTRODUCTION

Water is the most valuable resource of the earth. The plants, animals, human beings and all living creatures need water for their existence. In the world, one person in five lack access to safe drinking water. Many desalination techniques are available to provide freshwater to both urban and rural areas. But the challenge is to find a method suitable to provide uninterrupted supply of drinking water even for remote areas at a reasonable cost. Solar desalination is one of the cheapest methods to solve this problem. Solar still is widely used in solar desalination. On the basis of basin cover, single-basin solar stills can be classified into single slope solar stills and double-slope solar stills. To enhance the yield of the double-slope single-basin solar still, many modifications are being carried out. Due to environmental issues and limited fossil fuel resources, more and more attention is being given to renewable energy sources. In the recent years solar energy has been strongly promoted as a viable energy source. One of the simplest and most direct applications of this energy is the convergence of solar radiation into heat. Solar distillation is one of the cheapest methods to solve this problem. Single basin solar stills are mainly used for this purpose. In our study, pebbles, heat storage material in the basin (internal modification) and external reflectors (external modification) were used to focus additional rays into the still. The main objective of this study is to estimate the impact of internal modification and external modification on the performance of a double-slope single-basin solar still.

II. RELATED WORK

performance improvement of double slope solar still using heat absorbing materials by A.B. Damor & R. R. Shah [1] Performance investigation of single basin double slope solar still with and without phase change material and effect of reflector and fins by Akash A. Lokhande, S. M. Shaikh [2]. Efficiency improvement of flat plate solar collector using pcm, reflector, inserted twisted tape and wire coil by Anoop S Suresh, Anoop Joseph, Aswin Babu, Harikrishna V,

Joyal [3] experiment for Enhancing the productivity of double-slope single-basin solar still with internal and external modifications by S. Joe Patrick Gnanaraj, S. Ramachandran & David Santosh [4]

III. METHODOLOGY

The main methodology of the study is to achieve the above objectives of the experiment to be handle.

1. The conventional solar still was modified to accommodate fin liner and energy storage medium.
2. Detail experimental investigation was carried out to access the performance of the solar still for the following cases, the effect of
 - i. Water depth
 - ii. Fin liner
 - iii. Wick material
 - iv. Reflectors
3. Heat transfer analysis was carried out to study the internal and external energy flow like convective heat transfer from glass to ambient, conductive heat transfer from inner surface to outer surface, radiation heat transfer from glass to ambient etc.
4. An extensive experimentation has been carried out to analyse the convective and evaporative heat transfer coefficients to obtain the values of C and n through a thermal model using the experimental values of water and glass temperature and distilled output.
5. The thermal model used in this methodology is based on the method of regression analysis.
6. A mathematical model was developed by writing the energy balance equation of water mass, glass and basin liner, to predict theoretical temperature of glass, basin water, basin liner and the yield of distilled water, using the convective and evaporative heat transfer coefficients values which are obtained in thermal model.

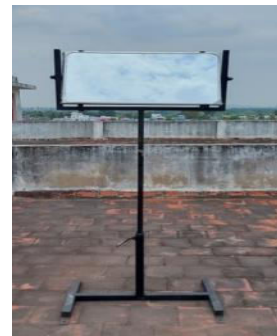


Fig 4.16

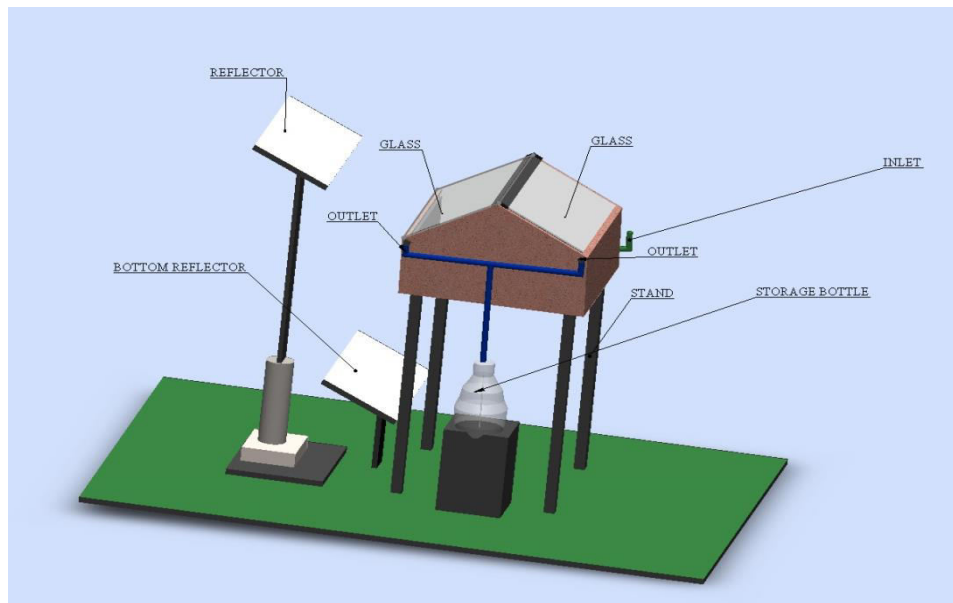
Fig 1 Round fin apparatus

Fig 2 Pin fin apparatus

Fig 3 square fin apparatus

Fig 4 adjustable Glass mirror

IV. EXPERIMENTAL SETUP



V. FORMULA USED

1. Evaporative heat transfer (water to glass)

$$Q_{e, w-g} = h_{e, w-g} (T_w - T_g)$$

2. Evaporative heat transfer coefficient (water to glass)

$$h_{e, w-g} = 16.273 \times 10^{-3} \times h_{c, w-g} (P_w - P_g) (T_w - T_g)$$

1. Saturated pressure for water

$$P_w = \exp \left(\frac{25.317}{T_w + 273} - 5144 \right)$$

2. Saturated pressure for glass

$$P_g = \exp \left(\frac{25.317}{T_g + 273} - 5144 \right)$$

3. Convective heat transfer coefficient (water to glass)

$$h_{c, w-g} = 0.884 (T_w - T_g) + (P_w - P_g)(T_w + 273)^{0.2689} \times 10^{-3} - P_w^{1.3}$$

4. The amount of distillate output of the solar still is

$$m_e = Q_{e, w-g} \times 3600 / L \text{ ml/m}^2$$

$$L - \text{latent heat of vapourization} = 2,372,000 \text{ J/kg}$$

VI. EXPERIMENTAL RESULTS

In the combination of black cotton, colour cotton and jute cloth with circular fin and pin fin of 20 mm, 30 mm water level, the per hour distillate production was about 650 ml/m²h at 1 and 2 pm the distillate production was more than 650 ml/m²h between 12 and 1 pm in still having square fin with black cotton of 10 mm water level and reflector angle of 135° produced the peak level production of 750 and 800ml/m²h respectively at 1 pm. The productivity of the single basin double slope solar still was very low. An attempt was made to enhance the productivity of the still by spreading heat storage materials in the basin or by using external reflector. The performance of the conventional still was compared with the performance of the modified solar stills. The following inferences were drawn.

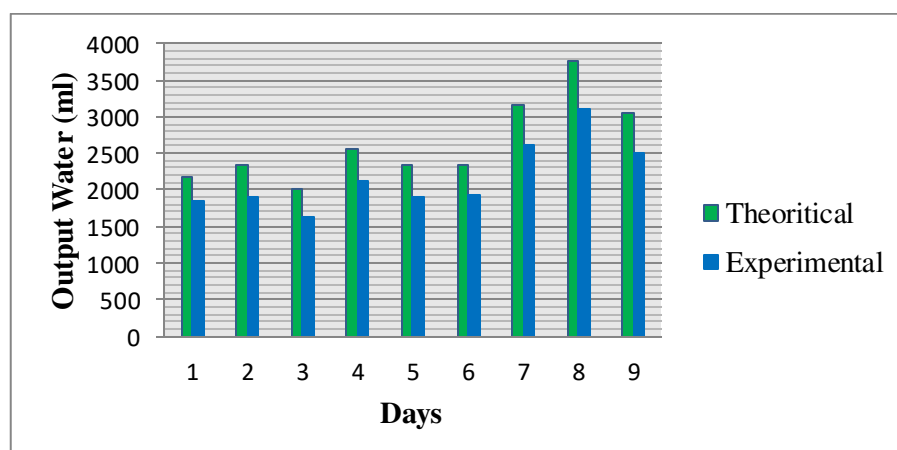
1. The productivity of the still with heat storage materials higher than the conventional still. The productivity rise in the still with reflector was around 70%

2. In the still with reflector, the increase in basin water temperature was quick in the forenoon and the peak level temperature of 63°C was attained at 1 pm itself. Compared to the still with heat storage material, it maintained higher water temperature upto 2 pm. As the sunshine declined, there was a drastic fall in water temperature.

3. In the still with heat storage material, there was a slow increase in basin water temperature in the forenoon and the maximum temperature of 52°C was touched at 2 pm only. After 2 pm, in the declining sunshine hours, it sustained higher water temperature compared to the still with reflector. The heat storage materials delayed quick drop in water temperature.

Table 1 Total quantity of water output

DAY	THEORITICAL WATER OUTPUT (ML)	EXPERIMENTAL WATER OUTPUT (ML)
1	2189.12	1850
2	2351.75	1915
3	1999.25	1630
4	2570.85	2115
5	2345.65	1910
6	2352.65	1935
7	3159.25	2610
8	3773.9	3095
9	3042.38	2500



Graph 1 Days vs Output Water

VII. CONCLUSION

The above investigation presents a clear view of productivity on the performance of Double slope single basin with external & internal modification. This section summarizes and presents the investigations carried out. The glass cover angle is equal to the latitude of the place for maximum desalination. The performance of the still with external

reflectors is comparatively high than the conventional stills. The performance of the still can be enhanced with the use of heat absorbing materials like Fin Apparatus with colour cotton, black cotton cloth and jute cloth a minor increase in the solar still productivity has achieved by increasing the environmental temperature. Increasing wind speed causes an increase in the solar still yield. The productivity of a Double-sloped solar still with external reflector has been found to be greater than that of a conventional one. At Day 8 Square fin with black cotton of 10 mm water level and reflector angle of 135° produced the peak level production of 750 and 800ml/m²h respectively at 1 p.m. Reflector was helpful in accelerating production rate during bright sunshine hours and heat storage material was effective in sustaining higher production rate during the declining sunshine hours. To conclude, modification in the single basin double slope solar still was really effective in enhancing the productivity of the still. For boosting forenoon production, external reflector was helpful and for sustaining higher production rate in the afternoon, the heat storage material was helpful. Modifying the conventional still with heat storage material and reflector will guarantee substantially higher distillate production throughout the day

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