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ANALYSIS OF DOUBLE SLOPE SOLAR STILL PRODUCTIVITY

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ABSTRACT: An exact simple and economical double slope solar still is discussed in this paper. A double slope solar still of 774.7×553.4 mm^2 has been constructed. The double slope solar still experimentally tested on distinctive summer days in Gorakhpur climatic conditions. Hourly inner as well as the outer glass temperature, ambient air temperature and solar radiations were recorded during the sunshiny days. Experimental surveys on productivity, internal heat transfer have been analyzed. Internal heat transfer studies shows that still design is worthy enough to reduce convective and radiative heat loss and thus confirms maximum evaporation.

Key Words: Solar still, fresh water, Glass, Evaporation, Productivity

1. INTRODUCTION

Fresh water is an instantaneous need for human life as drinking water purpose. The 97% of existing water sources are saline and contain harmful bacteria and 2% is frozen in glaciers and polar ice caps. Hence, only 1% of the world's water is useable for drinking and domestic utilities [4].Whatever be the still methods, the main attention is the temperature difference between the water in the basin and glass cover as the temperature gradient control the rate of condensation on the glass cover. Several methods were proposed such as the use of an external condenser and mixing a dye with the water in the basin [6]-[8].Both stills resulted in increased distillate yield but not without drawbacks. The use of an external reflector required an electric power supply and the effect of dye; the distillate quality has not been properly addressed. In the normal solar distillation process the evaporated water is condensed on the inner surface of the top cover by releasing its latent heat. However, the radiation and convection losses from the still are relatively small, which is leading to an increase in the cover temperature and reduction in the temperature difference between water in the basin and the cover. This mainly affects the rate of vaporization and productivity. The cover temperature can be reduced by flowing water over the glass cover [1]-[3].An optimum water depth of 3 cm is maintained inside the still [9]-[12] for maximum yield rate. Water flowing over the still, need additional mechanical support and valve system which in turn affect the cost effectiveness of the still. In this work, a very simple maintenance free low-cost double slope solar still has been constructed and it is tested experimentally. The distillate yield and the heat transfer coefficient have been calculated and the results are analyzed.

2. MATERIAL AND METHODS

A photographic view of double slope solar still and its sectional view are presented in .It's basically a symmetrical double slope solar still. The basin has been made by mild steel. Length and breadth of the still is given as 774.7mm and 553.4mm respectively. Bottom and sides of the still were painted black for good absorption of solar radiation.

Basin is placed at a height of 0.10 m from the ground so that sufficient insulation can be provided underneath to prevent heat loss. An inlet pipe of 1/2inch has been used on either side for pouring water into the still. Heat loss is reduced by providing a wooden case. The inter space between still and wooden case has been filled with glass wool to ensure minimum heat loss. The top cover of the still has been made by glass thickness of 5 mm. A 15°C slope is maintained for the top glass cover. Bushes were provided at each corner for perfect seating in surface. Water collection channel has been provided at the end of solar still.

Experiments were carried out in the month of March 2016.The experimental study started from 9:00 to 18:00 hours. The basin of the stills has been filled with saline water to the optimum height. Saline water has been poured into the still in the early morning in every day. The still has been operated in the shadow free place. Water inside the still gets heated up by the solar radiation and its temperature increases which influence to start the evaporation. The internal heat transfer in the still from basin water to condensing cover can take place mainly by convection, radiation and evaporation.

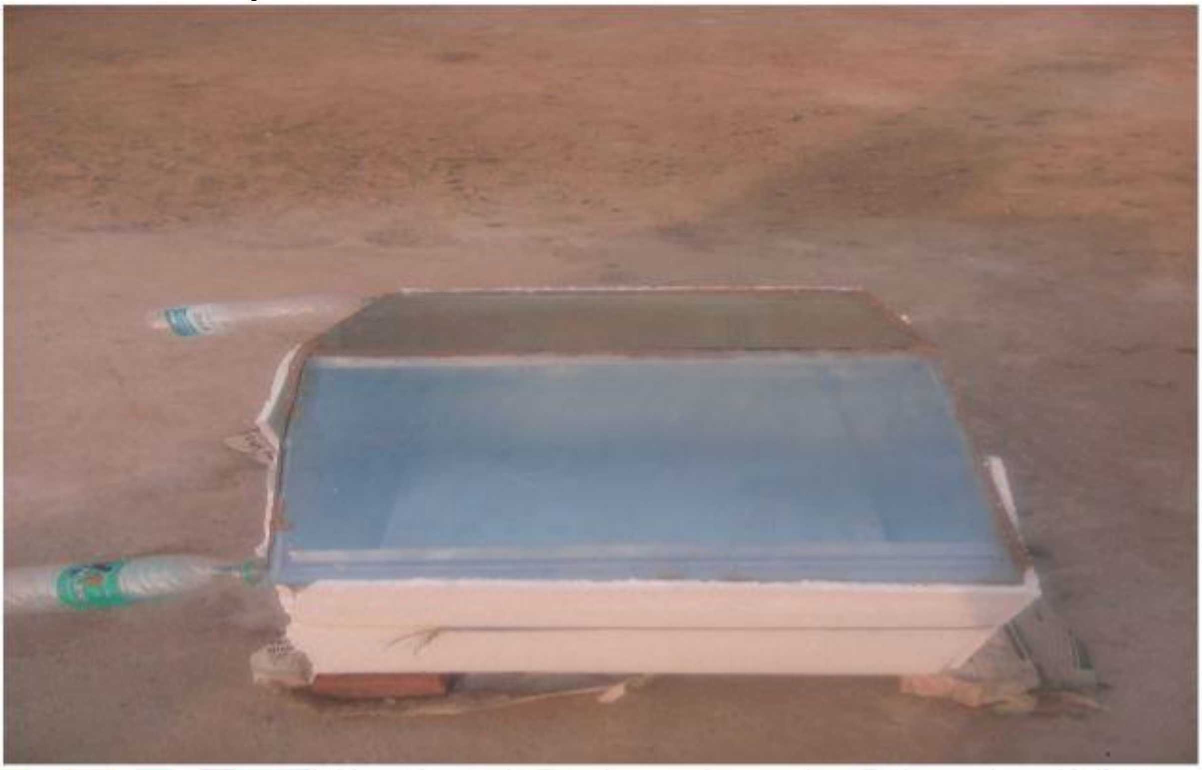

Fig. 1: Double slope solar still

A. CONVECTIVE HEAT TRANSFER

The heat transfer inside the still takes place by free convection. This is because the actions of buoyancy force due to the variation in density of humid fluid that occurs on account of temperature difference in the fluid, the rate of heat transfer from the basin water surface to condensing cover can be find by

$$q_{cw} = h_{cw}(T_w - T_g)$$

The coefficient h_{cw} can be found out from the following equation

$$h_{CW} = .884\left[T_w - T_{ciE} + \frac{(P_w - P_{ciE})T_w}{268.9 \times 10^3 - P_w}\right]^{1/3}$$

B. RADIATIVE HEAT TRANSFER

For a small cover inclination and large width of the still the water surface and cover are considered as parallel surfaces. The rate of radiative heat transfer from water surface to cover is given by

$$q_{rw} = h_{rw}(T_w - T_g)$$

The radiative heat transfer coefficient is given by

$$h_{ew} = \varepsilon_{eff}\sigma\left[(T_w + 273)^2 + (T_g + 273)^2 T_w + T_g + +546\right]$$

$$\sigma = 5.67 \times 10^{-8}\ \mathrm{W/m^2\,K^4}$$

$$\varepsilon_{eff} = \left[\frac{1}{\varepsilon_g} + \frac{1}{\varepsilon_w} - 1\right]$$

$$\varepsilon_w = \varepsilon_g = 0.95$$

C. EVAPORATIVE HEAT TRANSFER

$$q_{ew} = h_{ew}(T_w - T_g)$$

$$h_{ew} = 16.276 \times 10^{-3} h_{cwE} \frac{P_w - P_g}{T_w - T_g}$$

3. RESULTS AND DISCUSSION

Fig.2 shows the variation of radiation with respect to time. It increases with time and reaches a maximum range between 12.00 PM and 2.00 PM and then decreases. Radiation received during this study has been recorded in the range of 35.26 W/m² to 822.64 W/m².

Fig.3 shows the variation of temperature for inner cover and outer cover with respect to time. The variation of inner glass cover temperature has been in the range of 34°C to 58°C (east side) and 32°C to 55°C (west side). Similarly the variation of outer glass cover temperature has been in the range of 31°C to 52°C (east side) and 29°C to 51°C (west side).

Fig.4 shows the variation of temperature for water, air, with respect to time. The maximum temperature rise in water has been recorded as 62°C (east side) and 60°C (west side). Similarly the maximum observed air temperature was 28°C.

Fig.5 The productivity of the still mainly depends on wind velocity, perfect insulation and ambient temperature. In our experimental technique all the main parameters have been maintained for achieving the high distillate yield. The efficiency of any solar still depends on the yield rate. 279 ml of still output is measured from east side.

Fig.6 shows 201 ml of still output is measured from west side. Similarly like east side, inner glass temperature is always higher than outer glass temperature. Due to higher heat capacity of water, water temperature is always higher than temperature of inner and outer glass.. As the relative humidity decreases, still output will be increase. Maximum still output is obtained between 12 PM to 2 PM.

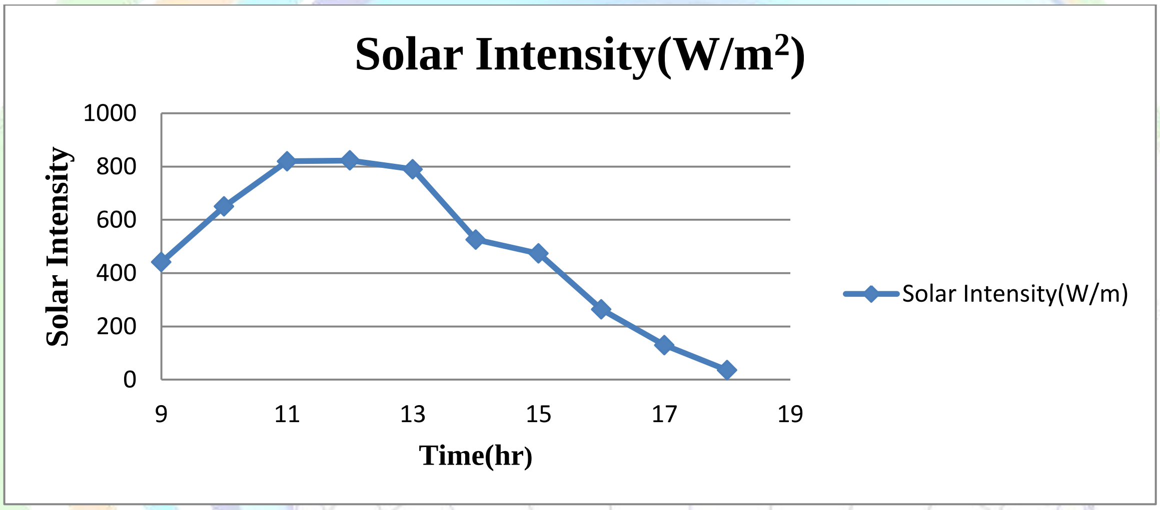

Fig.2: Solar Intensity vs. Time

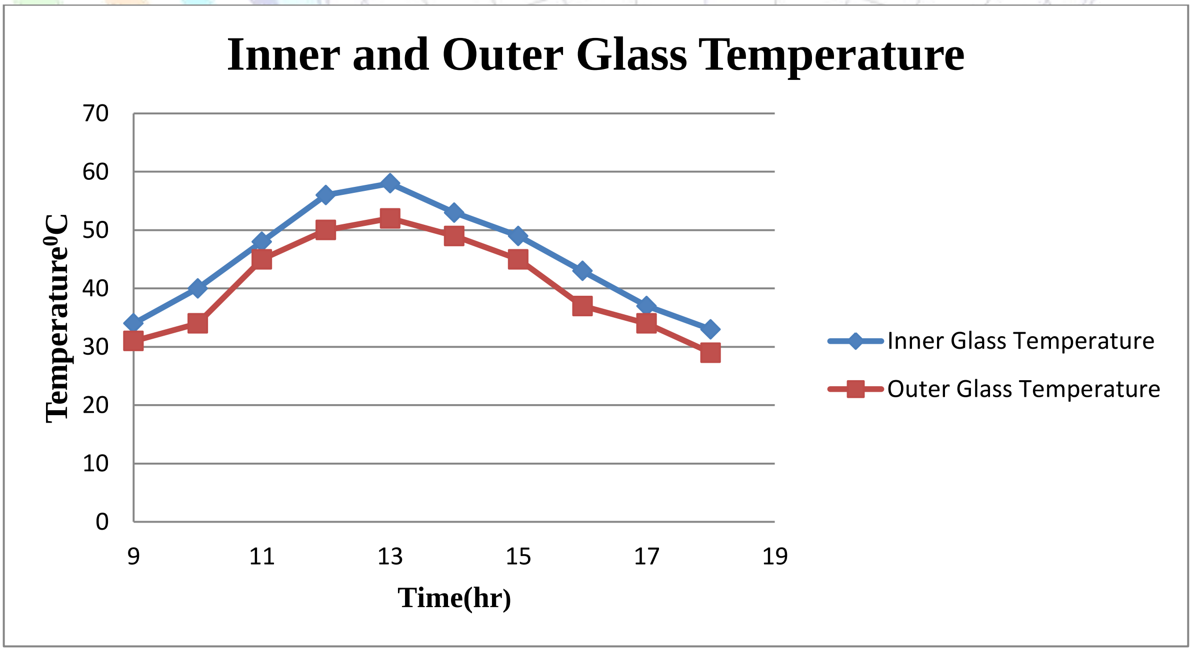

Fig.3: Inner and Outer Glass Temperature with respect to time

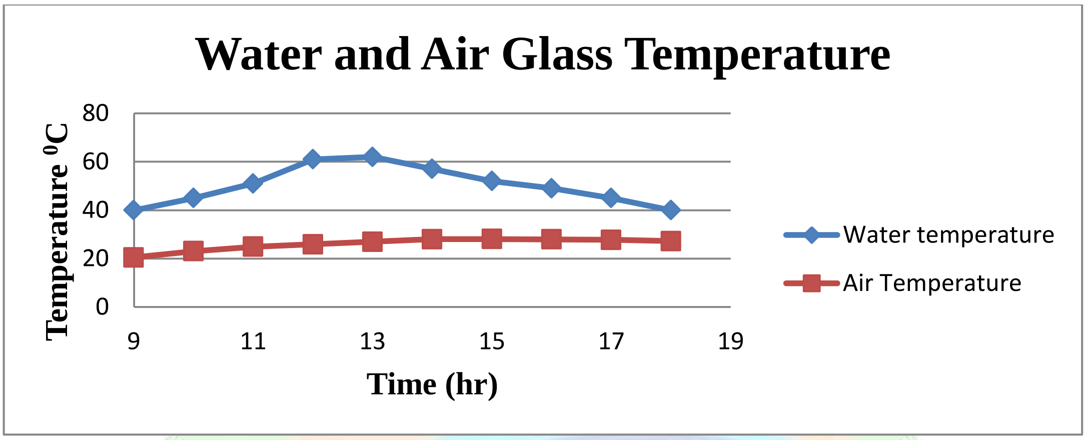

Fig.4: Water and Air Temperature with respect to time

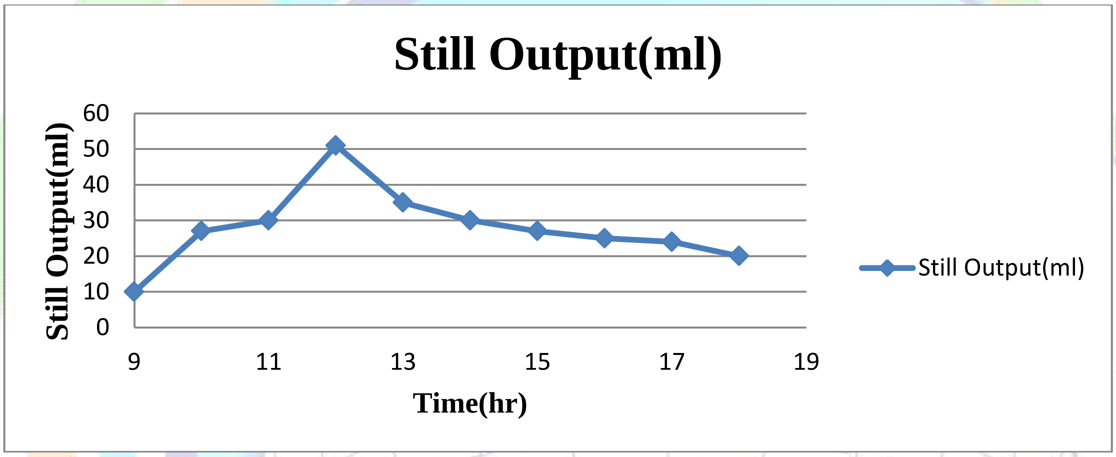

Fig.5: Still Output vs. Time (East)

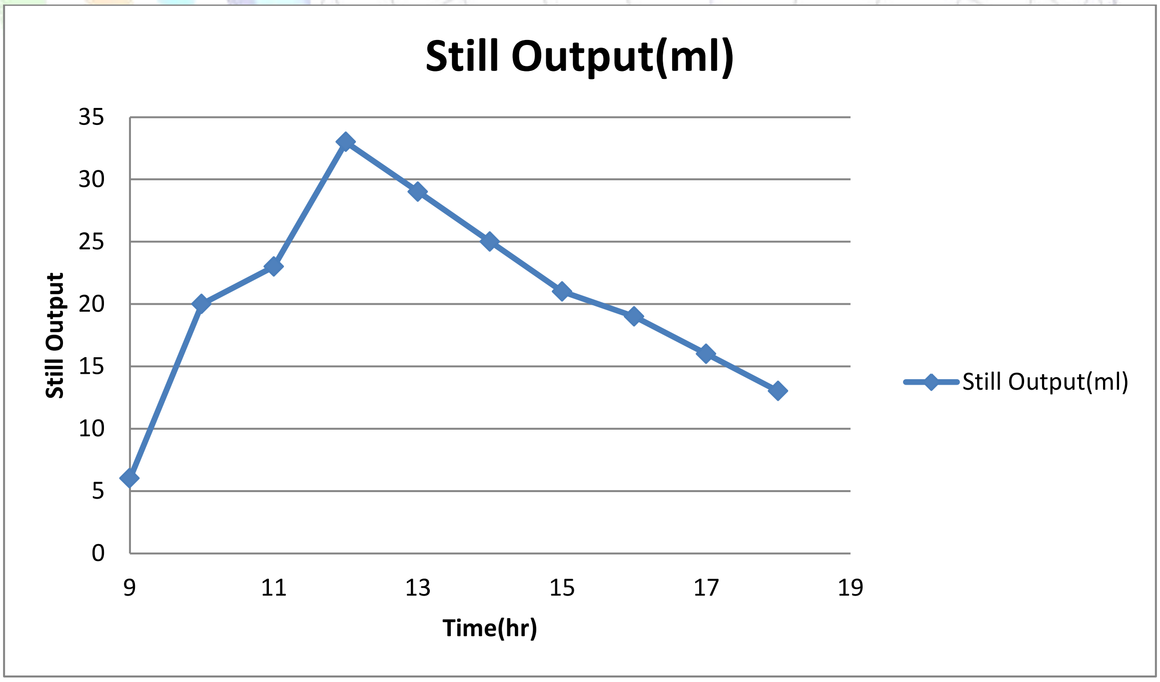

Fig.6: Still Output vs. Time (West)

4. CONCLUSION

A simple method of enhancing solar distillation is discussed in this paper. A double slope basin solar still has been fabricated and tested. The productivity of the still has been calculated as 279ml for east side and 201ml for west side.

The cost effective design is expected to provide the rural communities an efficient way to convert the brackish water into potable water. Producing fresh water by a solar still with its simplicity would be one of the best solutions to supply fresh water to villages and arid regions.

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