EXPERIMENTAL STUDY OF A SINGLE BASIN SOLAR STILL WITH WATER COOLING OF THE GLASS COVER

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ABSTRACT

A single basin solar still is a simple device to produce drinking water from easily available saline water. Because of its low productivity it is not popularly used. A lot of research work is undertaken to improve the productivity of the still. Heat transfer in a solar still mainly depends on the temperature difference between the evaporative water surface and the condensing surface for a given surface area. An attempt has been made to increase the temperature difference by reducing the condensing surface temperature. In this regard two similar, single basin double slope solar stills are taken for our study. Experimentation is performed in the premises of SHIATS-DU Allahabad. 17% gain is recorded in the distillate output due to cooled condensing cover.

Key words: Solar Still, Heat and Mass Transfer.

INTRODUCTION

Oceans are inexhaustible sources of water covering three fourth of the earth surface. But water in the oceans is of high salinity. Water shortage problems can be addressed by desalination of this water. Separation of salts from sea water requires lot of energy, which when produced from fossil fuel, can cause harm to the environment. Sea water desalination using solar energy gives viable solution to this problem.

Solar energy can be used for sea water desalination either by producing the thermal energy required to drive the phase change processes or by generating the electricity required to drive the membrane processes. The energy required for various desalination processes, as obtained from a survey of manufacturer’s data that the process with the smallest energy requirement is Reverse Osmosis with energy recovery. But this is only viable for very large systems due to the high cost of the energy recovery turbine. The next lowest is the RO without energy recovery and the MEB system. A comparison of the desalination equipment cost and the sea water treatment requirement as
obtained from a survey of manufacturers data. The cheapest of all the systems considered is the solar still. This is the direct collection system which is very simple to construct and operate. The disadvantage of this process is the very low yield [1]. The production capacity of a simple type solar still is in the range of 2-5 L/m²/day only. Number of methods is available to improve the productivity of single basin solar still. The required output from the still is the condensed water from the glass cover. The condensation is higher when the condensing heat transfer from the glass and the evaporation heat transfer from the basin water are high. Heat transfer within the solar still mainly depends on the evaporative surface area and the temperature difference between the evaporative surface temperature and the condensing surface temperature. In order to maximize the existing temperature difference between the water and the condensing surface, an attempt has been made to cool down the condensing surface by flowing water on the condensing surface. The glass cover temperature is reduced by a film of cooling water continuously flowing over the glass [2] or intermittent flow of cooling water on the cover [3]. The wind velocity is also affecting the cover temperature. At higher wind velocity the convective heat transfer from the cover to atmosphere increases due to increase in convective heat transfer coefficient between cover and atmosphere. This effect increases the condensing and evaporation rate and productivity of the still [4, 5].

EXPERIMENTAL SETUP

Figure 1 shows the photographs of two similar double slope solar stills kept on a single platform. The second photograph shows cooling of condensing cover by water flow arrangement. The experimental setup consists of a passive solar distillation unit with a glazing glass cover inclined at 26° having an area of 0.048m x 0.096 m. This tilted glass cover (3 mm thick) served as solar energy transmitter as well as a condensing surface for the vapor generated in the basin. To intercept the maximum insolation, the still was oriented in the East-West direction. Glass basin, made up of galvanized iron sheet, has an effective area of 0.72 m². The basin of the distiller was blackened to increase the solar energy absorption. A distillate channel was provided at each end of the basin. For the collection of distillate output, a hole was drilled in each of the channels and plastic pipes were fixed through them with an adhesive (Araldite). An inlet pipe and outlet pipe was 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. The glass panes of 3 mm thickness were used as covers for the still. All these arrangements are made to make the still air tight. A water tank of capacity 500 liter is kept at a height of 2 m to supply cooling water, to cool down the glass covers as in the photograph. The basin 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. The system has the capability to collect distillates from two sides of the still (i.e. East and West sides). Thermocouples were located in different places of the still. They record different temperature, such as inside glass cover, water temperature in the basin temperature and ambient temperature. In order to study the effect of salinity of the water locally available, table salt was used at various salinities. All Experiments were conducted during the month of September 2011 on several days. The experimental data is used to obtain the internal heat and mass transfer coefficient for double slope solar still.

Procedure:
The experiments were conducted on different thirty five days in the campus of the Sam Higginbottom Institute of Agriculture, Technology and Sciences Allahabad, India. All experiments were started at 08:30 AM local time and lasted for 05:00 PM. The following parameters were
measured for every 30 minutes for a period of 8:30 hrs. Inner glass temperature, vapor temperature, water temperature, ambient temperature and distillate output.

Water, glass and vapor temperatures were recorded with the help of calibrated copper constant thermocouples and a digital temperature indicator having a least count 1°C. The ambient temperature is measured by a calibrated mercury (ZEAL) thermometer having a least count 1°C. The distillate output was recorded with the help of a measuring cylinder of least count 1 ml. The solar intensity was measured with the help of a calibrated solarimeter of a least count of 2 mW/cm². The hourly variation of all above mentioned parameters were used to evaluate average values of each for further numerical computation.

Observations recorded after 10:00 AM are shown because the temperature difference between the basin water and the glass cover are positive. Due to higher glass cover temperature and lower basin water temperature in the morning, the temperature difference between basin water and glass cover is negative. Fig 3 shows the variation of solar intensity falling on the east and west side of the glass cover. As it is expected solar intensity on the east side is higher in the morning, and the maximum intensity is recorded at 11:30 AM. Fig 3 to 5 shows hourly average values of $h_{cw}$, $h_{cw}$, $h_{cw}$ Dunk and $h_{cw}$ Dunk calculated by using 8 hrs of experimental data. A TURBO C++ program was used to calculate the values of constants C and n used in the relation $Nu=C(GrPr)^n$. and convective and evaporative heat transfer coefficients by the present model and by the Dunkle model also. It is clear from fig 4 and fig 6 that the effect of cooling of condensing cover increases the convective and evaporative heat transfer coefficient.
Fig. 3 Variation of solar intensity of east side and west side of the glass cover for solar stills with cooled and without cooled condensing cover

Fig. 4 Variation of convective heat transfer coefficient for solar stills with cooled and without cooled condensing cover
Fig. 5 Variation of convective heat transfer coefficient calculated by Dunkle model for solar stills with cooled and without cooled condensing cover

Fig. 6 Variation of evaporative heat transfer coefficient for solar stills with cooled and without cooled condensing cover
Fig. 7 Variation of evaporative heat transfer coefficient calculated by Dunkle model for solar stills with cooled and without cooled condensing cover

CONCLUSION

A simple method to enhance the solar still productivity and still efficiency is proposed. The water film cooling method is used to modify the glass cover temperature in order to increase the rate of condensation. For experimentation two, double slope solar still of same size are taken and kept on a single platform for the purpose of comparative study. The average daily productivity of the still was 1.424 kg without glass cover cooling and 1.667 kg with cooling of the glass cover. The effect of film cooling on the thermal efficiency of solar still was also studied. It is observed that the thermal efficiency of the still is improved by 4%.

REFERENCES


