STUDY OF EFFECT OF CONDENSING COVER MATERIALS ON THE PERFORMANCE OF A SOLAR STILL

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ABSTRACT

In this work, an attempt has been made to study the effect of condensing cover material on the productivity of single basin solar still. Glass and acrylic sheet of 5 mm thickness were used as a condensing cover. Experiments were conducted on single basin single slope solar still with water depth of 1 cm in the basin. Convective and evaporative heat transfer coefficients were calculated for 30 minutes time interval. When the glass is used as condensing cover daily energy and exergy efficiency were recorded as 36.43% and 2.73%, whereas it is recorded as 16.84% and 1.52% when acrylic sheet used as a condensing cover.

Keywords: Condensing Cover Materials, Energy and Exergy Efficiency.

INTRODUCTION

Desalination is a process to produce the distilled water from brackish/saline water for the use of medical, drinking and charging of the batteries, etc. purposes by using solar energy called solar still. The solar distillation systems are mainly classified as passive and active solar still. In passive solar still, the water in basin is heated directly by solar radiation i.e., without feeding an external energy but in active solar still an additional thermal energy is feed in to the basin of passive solar still to increase basin water temperature.

One of the major challenges for putting solar still in practice is to work with the undesirable properties of glass as a material for mass production for solar stills [1]. Glass is heavy, brittle and has high replacement costs. On the other hand, plastic is light weight, relatively unbreakable, easy to transport and easy to process. Historically, plastic solar stills have been commercially more successful than glass solar stills and have sold over 400,000 units [2]. Still, due to higher amount of water production among other materials, glass has been the superior choice of material for its use as condensation surface inside a solar still. Factors like the type of material, roughness, inclination,
shape, transmittance, wiping and vibration of the condensing surface were found to have a significant impact on the production of water from the solar still [3-7]. The effect of condensing surface was covered in more detail [1-7]. The use of mechanically modified plastic against glass lowered the production of water by 18% [1]. The production of water from a solar still was found to be directly proportional to the thickness and thermal conductivity of condensing surface. The production of water decreased by 7% with an increase in glass thickness from 2 mm to 6 mm. The use of copper metal against plastic increased the production of water by 18%. [4] Dincer reported the relation between energy and exergy, exergy and environment, energy and sustainable development, and energy policy making and exergy in detail. The results obtain by Rosen et al.[9]. suggested that exergy should be utilized by engineers and scientists, as well as decision making and policy makers, involved in green energy and technologies in tandem with other objectives and constraints. In the literature, the exergy analysis of a passive solar still is carried out by Nunez et al.[10] in Mexico. There are very limited studies on the exergetic evaluation of active solar desalination system in the literature. Garcia-Rodriguez and Gomez-Camacho[11] performed an exergy analysis of a solar multi-effect distillation system (SOL-14 plant) located in Almeria solar research centre in southeastern Spain. Similarly Sow et al.[12] carried out energetic and exergetic analysis of a triple effect distiller by solar energy. This work quantifies power consumption per unit mass of pure water. Show et al. obtain exergetic efficiencies between 16-26% for a triple effect system. The exergetic analysis has been widely used in design, simulation and performance evaluation of energy systems reported by Hepbasli[13]. Hepbasli[13] made a key review on exergetic analysis and assessment of renewable energy resources for sustainable future for solar collector, solar thermal power plant, solar cooker, solar drying, solar desalination and hybrid PV collector. In the present work a single slope solar still is tested with two different condensing cover materials experimentally and their energy and exergy analysis is also performed.

EXPERIMENTAL SET-UP

A prototype single slope solar still having a horizontal tray which acts as absorber of 1 m² was designed and constructed. Tray was constructed using galvanized iron sheet of thickness 0.5 mm and later on painted in black. Testing was performed by placing the Single slope solar still operating in sunlight for a 24-h period. The work has led to the development of the single solar still and to a technical improvement. In order to achieve the maximum yield from the system, the still orientation should be the direction at which the highest average incident solar radiation is obtained. Experimental investigation of the Single slope solar still has shown that the productivity of the system was substantially increased in comparison with that of the basin type solar still. The present study was concerned with the energy and exergy efficiency based on evaporation from the water surface and based on condensation on the inner surface of the Single slope cover. Copper – constantan thermocouples are used, along with a digital temperature indicator, to record the glass temperature, water temperature and water vapor temperature in the experimental setup. These thermocouples, over a prolonged usage period, tend to deviate from the actual temperature. Therefore, they were calibrated with respect to a standard thermometer. A view of the condensing chamber and photograph of the experimental setup are shown in figure.1
Performance of single slope solar still

Energy efficiency

Instantaneous efficiency

The expression for instantaneous efficiency ($\eta_i$)

$$\eta_i = \frac{m e_{w}*L}{I(t)*A_w}$$

Overall thermal efficiency

The expression for overall thermal efficiency ($\eta_{passive}$)

$$\eta_{passive} = \sum \frac{m*L}{A_w \int I(t) dt}$$

Exergy efficiency

The general exergy balance for solar still can be written, Hepbalsi (2006)

$$\sum Ex_{in} - \sum Ex_{out} = Ex_{des}$$

or

$$Ex_{sun} - (Ex_{evap} + Ex_{work}) = Ex_{dest}$$

The exergy input to the solar still is radiation and can be written as

$$Ex_{sun} = Ex_{in} = A_w * 1(t)*\left[1 - \frac{4}{3} \left(\frac{T_a}{T_s}\right) + \frac{1}{3} \left(\frac{T_a}{T_s}\right)^2\right]$$

The exergy output of a solar still can be written as

$$Ex_{evap} = A_w * h_{ew} * (T_w - T_c) * \left[1 - \left(\frac{T_a}{T_w}\right)\right]$$

The exergy of work rate for solar still

$$Ex_{work} = 0$$

The exergy destructed in solar still can be written as

$$Ex_{dest} = M_w * C_w * (T_w - T_a) * \left[1 - \left(\frac{T_a}{T_w}\right)\right]$$

The exergy efficiency of solar still us defined, Hapbalsi (2006)

$$\eta_{ex} = \frac{Ex_{output \ of \ solar \ still} (Ex_{evap})}{Ex_{input \ of \ solar \ still} (Ex_{in})}$$
RESULTS AND DISCUSSION

Number of readings was taken on the setup and data were analyzed for two different days in a month.

**Fig.3:** Variation of Solar intensity with time of a day

Fig.3 shows the Variation of solar intensity with time on two different days of experimentation in the month of April.

**Fig.4:** Variation of wind speed with time of a day
Fig. 4 shows the Variation of wind speed with time on two different days of experimentation under consideration. Average wind speed on 01/04/2014 was 2.4166 and average wind speed on 23/04/2014 was 1.411 m/s.

Fig. 5 shows the Variation of temperature with time, water temperature with acrylic condensing cover is higher than water temperature with glass cover. Inner condensing cover temperature of acrylic sheet is higher than that of glass cover.

Fig. 6: Variation of convective heat transfer with time of a day
Fig. 6 shows the variation of convective heat transfer coefficient with time. Evaporative heat transfer coefficient (PM) is higher than evaporative heat transfer coefficient (DM).

Fig. 7 shows the variation of convective heat transfer coefficient with time. Evaporative heat transfer coefficient is higher when glass is used as condensing cover. The maximum value of exergy efficiency of glass cover is 6.64% whereas it is 3.54% for acrylic sheet condensing cover.

Fig. 8 shows the variation of energy efficiency with time of a day.
Fig. 8 shows the variation of energy efficiency with time. Energy efficiency is higher when glass is used as a condensing cover. The maximum value of energy efficiency of glass cover is 50.37% whereas it is for acrylic sheet condensing cover 29.13%.

Fig.9: Variation of exergy efficiency with time of a day

Fig. 9 shows the variation of exergy efficiency with time. Exergy efficiency is higher when glass is used as condensing cover. The maximum value of exergy efficiency of glass cover is 6.64% whereas it is for acrylic sheet condensing cover 3.54%.

Fig.10: Variation of distillate with time of a day
Fig. 10 shows the theoretical and experimental distillate with time for glass and acrylic sheet used as a condensing cover.

![Graph showing distillate with time](image)

**Fig.11:** Variation of distillate with time of a day

Fig. 10 shows the variation of experimental distillate output with time. It is observed that the daily productivity is higher when glass is used as the condensing cover than acrylic sheet condensing cover. A maximum of 3.925 liter/day is obtained with glass cover in comparison to 2.310 liter/day when acrylic sheet is used.

**CONCLUSION**

A single slope solar still with different condensing cover material is tested in the premises of SHIATS-DU Allahabad. Energy and Exergy analysis of the system is performed to find the maximum energy efficiency and exergy efficiency of the system. The following points can be concluded from the present work.

- The exergy efficiency of a single slope solar still is lower than energy efficiency it is due to lower evaporative heat transfer rate.
- The maximum instantaneous energy efficiency for solar still with glass as a condensing cover is 50.30% when as it is 29.136% for acrylic sheet condensing cover.
- The maximum instantaneous energy efficiency for solar still is 6.64% when glass is used as a condensing cover and 3.54% when acrylic sheet condensing cover.
- Daily productivity increased by 71% when glass is used for condensing cover.

**REFERENCES**


