Perspectives in Science (2016) 8, 191—194

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/pisc

Performance enhancement of modified solar still using water sprinkler: An experimental approach ☆

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Received 14 January 2016; accepted 8 April 2016
Available online 25 April 2016

KEYWORDS
Solar still;
Single slope;
Solar energy;
Performance;
Water productivity

Abstract In this communication, existing design of single slope solar still has been modified, developed and tested. The modifications in conventional single slope solar still include (i) inside walls painted with white colour and (ii) attachment of water sprinkler with constant water flow rate of 0.0001 kg/s on the glass cover. The performance of modified single slope solar still has been evaluated and compared with conventional solar still. Experiments have been carried out on both modified and conventional single slope solar still for 05 cm water depth in the month of April at Jabalpur (Latitude 23°18′ N; Longitude 79°95′ E) India. The distilled water output was recorded 2940 ml and 3541 ml from conventional and modified solar stills respectively. Water productivity or yield of single slope solar still is increased by 20% from above modifications. The overall efficiency is increased by 21% over the conventional solar still.

Introduction

The availability of fresh water is diminishing continuously day by day because of global warming and climate change. Same time, its requirement is increased rapidly all over the world due to rapid growth of population. Therefore, the availability of good quality of drinking water is the major challenge in front of developing as well as developed countries. About 97.5% of the total water available on the earth having salt and harmful bacteria, nearly 2% is frozen in glaciers and polar ice caps (Kumar et al., 2015). This water cannot be directly used for drinking purpose, if so; it causes a serious damage to health. Here is the need of technology for distilling of brackish and saline water to purify drinking water. The solar still is one of the prominent, cheapest and environmental friendly methods. Number of designs have

☆ This article belongs to the special issue on Engineering and Material Sciences.

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http://dx.doi.org/10.1016/j.pisc.2016.04.029

been suggested and constructed to improve the purified water output per unit area. Many researchers have shown their interest to enhance the performance by maintain the higher temperature difference between solar still basin and glass cover, so that the rate of vaporisation can be increased (Velmurugan et al., 2000). Tiwari and co-authors (Sodha et al., 1980) have reported an improvement by increasing the temperature of water in the basin using active and passive methods or by decreasing the temperature of the glass cover or combination of the both. Dimari et al. (2008) have discussed the effect of thickness of glass cover and different condensing cover material. They have suggested that glass is the best performed material for solar still. Abdullah (2013) reported comparative study of experimental performance between stepped solar still coupled with solar air heater over the conventional solar still. They also study the effect of the water flow on the glass cover. It was examined that water productivity increased by 112% over conventional still, Hijleh and Mousa (1997) have numerically investigated the effect of water film cooling parameters on the performance of the solar still. Improvement in performance was reported in still efficiency up to 20%. It is also investigated that the ambient wind velocity has significant effect on the still efficiency. Tenthani et al. (2012) have conducted experiments on two solar stills with different colour paint on inner surfaces. One is painted white and another is painted black on the inside walls of the solar still. It is concluded that white painted solar still was found 6.8% more efficient. The productivity of single slope solar still can also be enhanced by coupling a shallow solar pond (SSP) to the still (El-Sebaii et al., 2011). In some research Glass has been used as a preferable choice of material for its use as a condensation surface in solar still as it gives higher water yield than other materials (Bhardwaj et al., 2013).

Authors have not find combination of white painted inside wall and sprinkling of water on glass cover of conventional solar still in literature. This is an attempt for experimental investigation on modified conventional single solar still with white painted wall and sprinkling of water on glass cover. In this communication both stills were critically examined and discussed with respect to different operating parameters, and how they have related to each other.

Material and method

Two geometrically identical solar stills were designed and fabricated at Government Engineering College, Jabalpur (Latitude 23°.18′ N, Longitude 79°.98′ E) India. Two sets of experimentation were conducted for conventional solar still and modified conventional still. The experiments were carried out on dated 24 April 2015 from 07 AM to 06 PM. various operating and ambient parameters have been recorded hourly. An actual photograph of the experimental setup (modified and conventional solar still) is shown in Fig. 1.

Both the solar stills were fabricated in similar way and identical in geometry. These have basin area of 1 m^2, height of back-side wall is 527 mm and height of front-side wall is 100 mm. Basins of stills are made from galvanised iron sheet having a thickness 1 mm. The bottom and the side walls are insulated with layer of glass wool (20 mm thickness) to reduce the heat loss from the solar still to atmosphere.

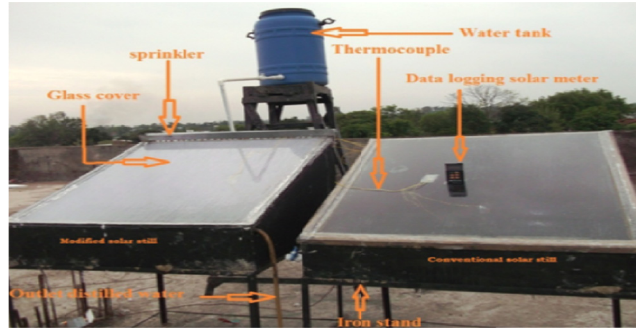

Figure 1 Experimental setup of solar stills.

Ply-wood of 15 mm thickness is used for making outer layer of solar still. The top of both the stills have been covered by glass of 4 mm thickness. It is inclined at 23° to the horizontal which is latitude of the Jabalpur. Leakage of heat and water vapor from space between glass cover and sides edges of solar still are prevented by filling glass putty. Modified single slope solar still have following alteration: (i) all vertical internal walls are painted with white colour up to water level to increase reflectivity of solar radiation which increases the utilisation of solar energy. (ii) Water sprinkler is fitted at the top of the glass to reduce the glass temperature which enhances the rate of condensation.

The basin was black painted up to water level to absorbed maximum solar energy like in conventional solar still. In the conventional solar still, all the side walls and bottom surface were painted black. As per the literatures water flow rate was kept 0.0001 kg/s during the experimentation to avoid the wastage of water. The water flow rate is adjusted in such a manner that the water gets evaporated during the path of flow on the glass surface. Little amount of water is able to reach at the bottom of the glass. Global solar radiation was observed at inclined glass surface on hourly basis. The temperature has been observed with the help of K-type thermocouples at five different places are: water, inside glass, outside glass, vapor field and ambient. The water depth of 05 cm is kept in both the solar stills. The hourly distillate from both solar stills are also collected and measured hourly during sunshine hours. The distillate output after sunset is measured collectively on next day morning up to 6 AM. Observed parameters were used for performance analysis of solar stills.

Results and discussion

The various temperatures and distillate output have been measured in this experiment at constant water depth of 5 cm on hourly basis. The comparative analysis has been done for both the modified and the conventional solar stills. The variation in solar radiation and ambient temperatures with respect to time of the day during experimentation is shown in Fig. 2. The solar radiation varied from 103 W/m^2 to 878 W/m^2. It gradually increases from morning hours and reached on highest value of 878 W/m^2 at 12 PM. The ambient temperature varied from 29 °C to 38 °C. The highest value of ambient temperature was obtained nearly at 1 PM.

Fig. 3(a) and (b) shows the hourly variation in water basin temperature, water vapor temperature, and inner and outer