# Performance Improvement of Solar Stills via Experimental Investigation

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**Received: 13 November 2011, Revised: 1 Mars 2012, Accepted: 9 July 2012**

**Abstract:** There is always a need to increase a distillate output of Solar still. The distillate output of solar stills is expected to increase by applying plates inside solar stills. Hence, an experimental study is conducted to investigate the improvement distillate output of basin solar stills by increasing the effective surface area with the help of different plates. For this purpose, three solar stills are developed by locally available materials. The first solar still is a conventional type, the second is made of Aluminium plate while the third one is made of Galvenized Iron plate. Performance of solar stills having aluminium plate and Galvenized iron plate is tested and compared with conventional solar still under the same climate conditions of Mehsana, Gujarat. The three solar stills are tested at two different situations: still at the same water depth (40 mm) and stills having the same quantity of brackish water (30 L & 40 L). Results indicate that, distillate output of solar still having aluminium plate is higher than conventional solar still and solar still having Galvenized iron plate. Moreover, it is found that the average distillate output of water increases up to 45 % and 15 % of conventional solar still with respect to solar stills having aluminium plate and Galvenized iron plate respectively.

**Keywords:** Aluminium Plate, Distillate Output, Galvanized Iron Plate, Solar Still

**Reference:** Panchal, H. N., and Shah, P. K., “Performance improvement of solar stills via experimental investigation”, Int J of Advanced Design and Manufacturing Technology, Vol. 5/No. 5, 2012, pp. 19-23.

**Biographical notes: H. N. Panchal**, received his BSc and MSc in Engineering from Govt. Engg. College, Modasa and L D College of Engineering, Gujarat in 2004 and 2006 respectively. He is pursuing his PhD in Solar Thermal Engineering from KSV University, Gandhinagar, Gujarat under guidance of Dr. P. K. Shah. His area of interest includes Internal Combustion Engine, Automobile Engineering, and Solar Thermal Engineering. **P. K. Shah** has completed his BSc and MSc in Mechanical Engineering at Gujarat University. He obtained his PhD in Solar Heat Transfer from North Gujarat Uni. He has teaching experience of 39 years in various Engineering Colleges in Gujarat. The subject of his interest includes Heat and Mass Transfer and Energy Sources. Presently, he is working as Principal in Silver Oak College of Engineering and Technology, Ahmedabad.

## 1 INTRODUCTION

The supply of drinking water is one of the major problems in developing countries as well as under developing countries. Clean or potable water is a basin human necessity and without water life will be impossible. Nowadays the pollution in rivers and lakes by industrial effluents and sewage disposal has resulted in scarcity of fresh water in many big cities around the world. In addition, with an ever increasing population and rapid growth of industrialization, there is a great demand of fresh water, especially drinking [1].

There are also reviews made by some researchers on various solar thermal collectors and their applications on solar stills [2-5]. It is shown that solar distillation depends on factors such as sunshine duration, solar radiation, etc. Badran [6] conducted an experiment with single slope solar still with climate conditions of Jordan with change in parameters. Abdallah et al., [7] as well as Abdullah and Badran [8] made a modification of solar still by adding a Sun tracking system. They showed that, there is a considerable improvement in distillate output of solar still.

Some other investigators used different dyes [9-11] in solar still. They used different dyes, and proved that the black dye increases the distillate output of solar still compared to other dyes. Inlet temperature of water can also increase the distillate output of solar still, hence some researchers [12-14] recommended various external sources like flat plate collector, storage tank, etc; they showed that, there is a great improvement in solar still ranging from 25 % to 200 %.

Abu Hiljeh and Rababah [15] made an experimental performance of solar still with different size of energy absorbing materials like black coal, black steel cubes. They found that there is a great improvement in distillate output of solar still from 18% to 273% compared with conventional solar still. Some researchers have also made experiment with some solid materials or energy absorbing materials inside solar still [16], [17].

From above literature review, it is confirmed that solar still is a very important device to convert brackish water into drinkable water. The main aim of the present study is to evaluate the effect of various energy absorbing plates in order to improve distillate output of solar still through improvement in thermal conductivity. These plates are Aluminum and copper plates in climate conditions of Mehsana Gujarat.

## 2 EXPERIMENTAL SET UP

In this research work, three solar stills were designed and fabricated to study and compare the performance of the solar stills, as shown in Fig. 1. The first one is a solar still having Aluminum Plate, and the second is solar still having Galvenized iron plate while the third is a conventional solar still. The conventional still (a single basin) has a basin area of 1 $m^2$ (50 cm×200 cm). The still is made of iron sheets (2.5 mm thickness). The whole basin surfaces are coated with black paint from inside to increase the absorptivity.

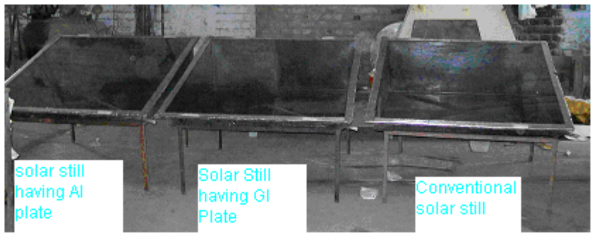
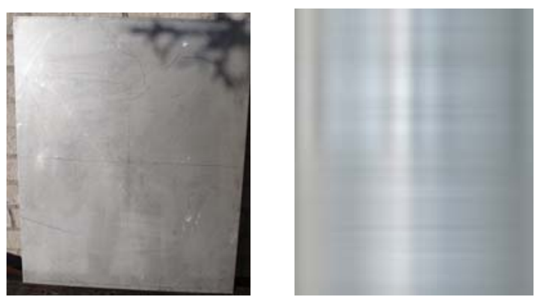



**Fig. 1** Experimental Set up of Solar stills

Moreover, the still is insulated from the bottom to the sidewalls with sawdust 5 cm thickness to reduce the heat loss from the still to atmosphere. The insulation layer is supported by a wooden frame, and the basin is covered with a glass sheet of 3 mm thickness inclined at nearly 30° horizontally. Solar stills were placed on the terrace of "Geetanjali Society", Mehsana. It has latitude and longitude of Egypt (23º 43' N, 72º 37' E) in order to maximize the amount of incident solar radiation and improve distillate output. The whole experimental setup is kept in the south direction to receive maximum solar radiation throughout the year.



(a) (b)

**Fig. 2** Photograph of plates used in solar stills a)Aluminum Plate b) Galvenized iron Plate

Feed water tank of 50×50×50 $cm^3$ is used to feed water to all three solar stills. The feed water tank is connected to the main line which is divided into three feed water lines.

A flow control valve is integrated at each line inlet in order to regulate the flow rate of water. The experimental setup is suitably instrumented to measure the temperature at different points of the still (brine, absorber and glass cover temperatures), total solar radiation and the amount of distillate water. The temperatures have been measured using calibrated copper constantan type thermocouples which were integrated with a modeler programmable logic control (MPLC) to measure all solar stills temperatures at the same time. The solar radiation intensity is measured instantaneously by a solarimeter. The digital air flow/volume meter is used to measure the wind flow velocity.


**Fig. 3** Data logger used in Experiment

Table 1 shows the different instruments as well as their accuracies used in the solar stills experiment.

**Table 1** Experimental instruments with accuracy, range and errors percentage

| Instrument | Accuracy | Range | % Error |
|---|---|---|---|
| Solarimeter | ± 1 $W/m^2$ | 0-4000 $W/m^2$ | 0.5 |
| Temperature Indicator | ± 0.1° C | 0-200° C | 0.5 |
| Measuring Flask | ± 1 ml | 0-5000 ml | 1 |
| Anemometer | ± 0.1 m/s | 0.2 to 40 m/s | 1 |

## 3 EXPERIMENTAL PROCEDURE

Experiments of solar stills were conducted at Geetanjali Society, Mehsana, Gujarat and carried out from 9 AM to 8 PM, during July 2011. The solar radiation, atmospheric temperature, basin temperature, glass temperature and distillate water were measured every 1 hour for maintaining steady state conditions. However, the accumulated productivity during the 24 hour was also measured for each experiment. All measurements were performed to evaluate the performance of the stills under the climate conditions of Mehsana. During the experiments, the ambient climatic conditions (solar radiation, ambient temperature and wind velocity) were also measured.

Saline water in still was heated by solar radiation. The established water vapor was condensed at the inner glass surface and the water droplets were glided along the glass. The condensed water was collected in a calibrated flask. The depth of the saline water in the solar stills was maintained constant manually using the feed water tank and control valves. The present experimental study was aimed to study the effect of still surface area variation on fresh water productivity and the efficiency of basin still at two different situations. The first was equalizing the saline water depths inside the three tested stills, while the second case was conducted at equalizing the saline water volume in the three tested stills.

## 4 RESULT & DISCUSSION

Depending upon the weather conditions of Mehsana, Gujarat, wind flow speed was varied from 1.5 to 4.5 m/s at different days of June 2011 and solar insolation was also varied from 30 to 1200 watt/$m^2$. Here solar stills were tested at two situations: at the same water depth (4 mm) and at the same bulk of water (40 L).

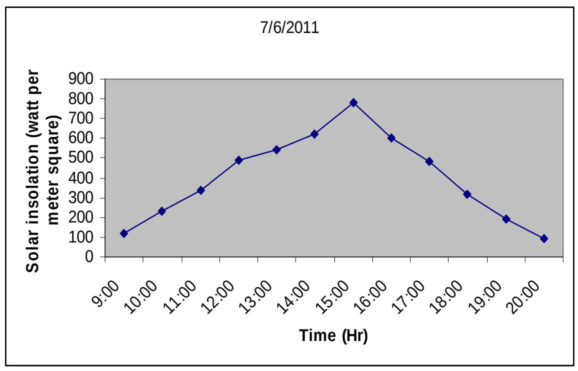



**Fig. 4** Comparison of solar insolation and Time Climate conditions of Mehsana (7/06/2011)

Variation of solar insolation versus Time (Hr) is shown in Fig. 4. The variation pattern remains the same for all solar stills, because the solar insolation incident is uniform on all solar stills.

Fig. 5 shows basin water temperatures of all solar stills versus Time (Hr). It is shown that, the temperature is continuously increasing as the time increases till a maximum value during afternoon (due to the fact that maximum solar radiation on earth surface starts to drop during afternoon). It is also observed that maximum value in basin temperature is reached during period of 3:00 PM to 4:00 PM for all solar stills due to great access of solar radiation as well as warming of solar stills since the early morning to afternoon (maximum heat capacity available). It also shows that, highest temperature gain is achieved by solar still having Aluminum plate, compared with solar still having GI plate as well as Conventional solar still, which is due to its higher thermal conductivity.

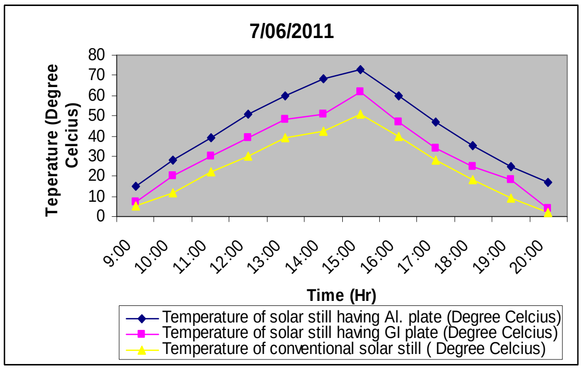



**Fig. 5** Comparison of hourly variation of basin water temperature and Time at constant water depth of 40 mm in climate conditions of Mehsana

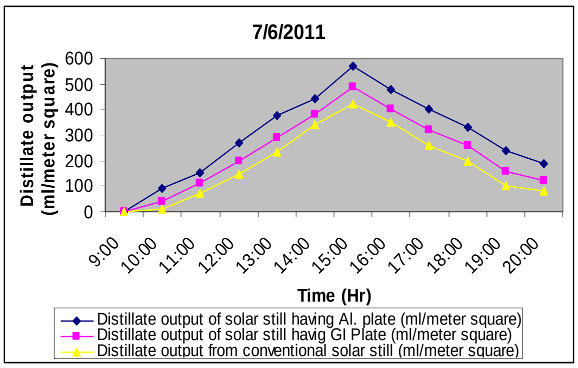



**Fig. 6** Comparison of hourly variation of distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana (07/06/2011)

Fig. 6 shows comparison between hourly distillate outputs gained in all three solar stills namely solar still having Al. plate, GI plate as well as conventional solar still. It shows that, the maximum distillate output is gained in afternoon. Moreover it is observed that, the initial reading of output for all three at 9:00 AM is zero, where it is continuously increasing until 3:00 PM and then gradually decreasing. Here, the highest distillate output is produced by solar still of Al. plate (20.05 L), because it has lowest quantity of brackish water inside the solar still, so it takes less time for evaporation as well as condensation. Solar still having GI plate has brackish water of (25.20 L) and conventional solar has quantity of (29.50 L). From the quantity of brackish water inside the solar stills, it is shown that, due to large amount of brackish water inside the conventional solar still, it require highest time for evaporation as well as condensation, hence quantity of distillate output produced from conventional solar still is least and highest for solar still having Al. Plate.

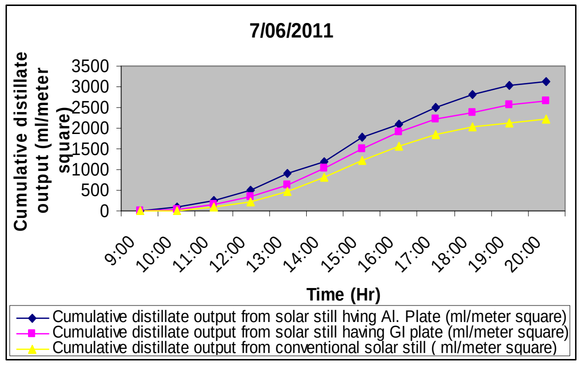



**Fig. 7** Comparison of cumulative distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana (07/06/2011)

Fig. 7 shows comparison of accumulated distillate water versus Time for all solar stills. It is shown that, highest accumulated distillate water is gained by solar still having aluminum plate and least gained by Conventional solar still.

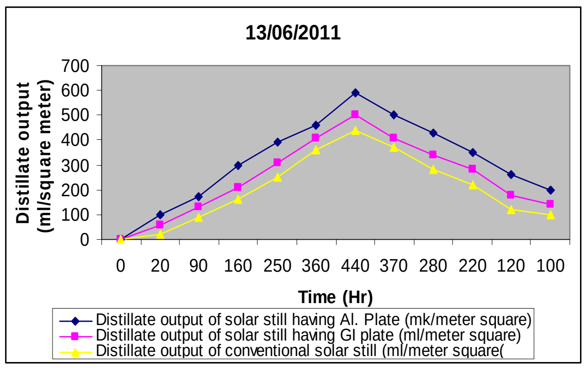



**Fig. 8** Comparison of hourly variation of distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana (13/06/2011)

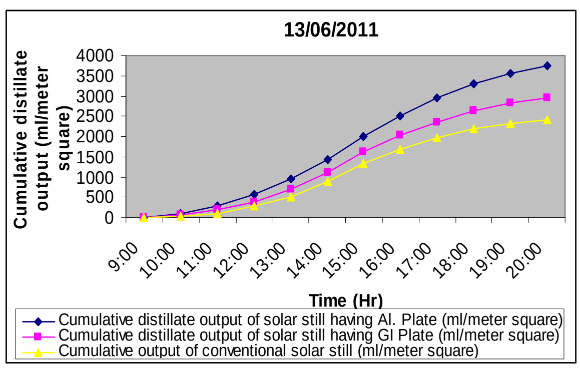



**Fig. 9** Comparison cumulative distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana (13/06/2011)

**Table 2** Comparison of tested solar stills of 40 mm depth of water as well as 30 L storage of brackish water in solar stills

| Date | Conventional Solar still | Solar still having GI Plate | Solar Still having Al. Plate |
|---|---|---|---|
| Distillate output at water depth of 40 mm and Quantity of 30 L water | | | |
| 7/06/2011 | 2300 | 2600 | 3212 |
| 13/06/2011 | 2410 | 2970 | 3500 |
| 19/06/2011 | 2540 | 3100 | 3703 |

Table 2 represents the comparison of solar stills at three particular days of June 2011. It shows that improvement in distillate output of nearly 10% in solar still having GI plate and 40% of solar still having Al. plate, compared with conventional solar still at 7/06/2011. It is calculated that on 13/06/2011 as well as 19/06/2011, the average increase of distillate output of of solar still having GI plate and solar stills having solar still having Al plate are 15% and 45% respectively, compared with conventional solar still.

## 5 CONCLUSION

The performance of three solar stills namely solar still having Al plate, GI plate as well as conventional solar still were evaluated experimentally in climate conditions of Mehsana, Gujarat. Experimental results indicated that the performance of conventional solar still can be improved by applying plates made of Aluminum as well as Galvenized Iron. Average distillate output has increased up to 45% by using Aluminum plate and 15% by using Galvanized Iron plate at brackish water of 40 L and depth of water of 40 ml.

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