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*Research Paper*

# MODIFIED SOLAR STILL WITH SPRAY SYSTEM: AN EXPERIMENTAL ANALYSIS

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Demand of energy is increasing in day to day life. We require energy for doing many tasks in industries, agricultural, domestic activities and laboratories. We are continuously using conventional sources of energy which will be exhausted in next couple of years. Hence the use of non-conventional sources ought to be our priority. Nowadays, the majority of the consumed energy all around the world comes from conventional fossil fuels like coal, natural gas, crude oil etc. Solar assisted devices are bright hope for the future energy requirement of the world. Among various solar applications, solar still seems to be very feasible device for the pragmatic conditions. Solar still is basically a device which is used for the purpose of converting brackish water into fresh water. In the present work, a solar still has been designed and fabricated which contains an extra glass apart from the upper glass. Inner glass was kept at 59° to the base of the modified solar still. Spray system was used to increase the distillate. The performance of this modified solar still was found to be much better in comparison to the stepped solar still. It was observed that the hourly distillate of solar still with spray system was higher than the conventional solar still. The cumulative distillate of the modified solar still was 2.1 litres for the normal day.

Keywords: Solar still, Water desalination, Solar energy, Renewable energy sources

## INTRODUCTION

Clean water is one of the most fundamental requirements for human beings along with food and energy. Although water on the earth constitutes three-quarter of the world's surface, approximately 97% of total water resource is brackish, and only 3% is fresh water suitable for drinking, industrial and agriculture needs. Now days the freshwater scarcity has become a

profound worldwide crisis predominantly in remote areas due to increasing of energy crisis and global warming. In the present circumstances, utilization of solar energy for desalination shall be the best solution for rural as well as urban areas (Ranjan and Kaushik, 2013). Water distillation has been recognized as a good approach to get portable fresh water. To overcome this issue, utilization of renewable and sustainable

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energy source such as solar radiation seems to be a promising way for supplying high-quality fresh water. Solar distillation is one of the best methods for purifying brackish water. Solar still is a device which is widely used in the solar distillation process, but the efficiency and productivity of a solar still is very low as compared to other distillation processes, hence it is necessary to enhance the productivity of solar still by improving the conventional design parameters and operational procedures. Extensive research has been carried out in the past to improve the productivity of these stills. In an inclined still, water flows from the top to the bottom of the absorber surface. To maintain the uniform thickness of water, a wick, which draws water through capillary effect, is used. Stills with inclined absorber surfaces are reported to have significantly higher productivity than basin type stills (Aybar Egelioglu Fuat and Atikol, 2005). Nowadays, solar distillation is widely employed due to its advantages such as sustainability, environmental friendliness, easy operation and low-cost. Solar still can be broadly divided into passive and active types. Passive stills are further divided into basin and inclined types. There are several works presented in literature, to improve the performance of an inclined wick type solar still.

Yeh Ho-Ming and Chen Lie-Chaing (1986) studied that the productivity of the wick-type solar distillers varies with the effects of climatic, design, and operational parameters on the. Minasian and Al-Karaghoul (1994) studied the performance of a new type of still formed by connecting a small conventional basin-type (installed in shadow and having an opaque cover) with a wick-type solar still. As compared with other solar distillation systems, a single-effect,

basin-type horizontal passive solar still is comparatively cheaper (Ranjan and Kaushik, 2013). Agrawal *et al.* (2017) conducted a theoretical and experimental study at the central Indian location of Rewa, M.P. India. They presented a detailed comparison of the theoretical and the experimental results obtained for a single sloped basin type solar still. Various results for different parameters of solar still like basin water temperature, glass cover temperature, distillate output, evaporative, convective and radiative heat transfer coefficients and attenuation factor were obtained for basin water depths ranging from 2 cm to 10 cm. Kaviti *et al.* (2016) found that conventional basin still has very low productivity. To improve the productivity we need optimization of glass inclination, absorber plate area, and free surface area of water and depth of water. The main difficulty in conventional still is maintaining minimum depth and large surface area of water. They found that the Inclined solar still is alternative to increase the surface area of water and maintain minimum depth. Researchers have put efforts to develop various designs of inclined solar stills to maintain the minimum depth of water using wicks, steps in the stills to increase the productivity.

Kuldeep Nayi and Kalpesh Modi (2018) have focused on development of various designs of solar still in order to overcome limitations possesses by conventional single basin single slope solar still. They found that the Pyramid solar still is one of the best solar still as compared with others. They reviewed the development in the field of pyramid solar still as well as the various techniques to improve the performance of still. Ahsan *et al.* (2014) developed simple triangular solar still. This still was made of waste material as Polythene for cover PVC pipe for frame, Perspex for trough, Nylon rope, and transparent

scotch tape to seal the solar still. The daily water production of 1.6 and 1.55 kg/m<sup>2</sup> for 1.5 and 2.5 cm of water depth respectively were obtained.

Factors influencing the still productivity were investigated by Cooper (1973) who indicated that the upper limit of solar still productivity both *et al.* (1981) compared the measured values with a theoretical analysis of heat and mass transfer processes for basin type and tilted wick type and indicating the superiority of the tilted wick still and carried out measurements of performance parameters of both basin-type and tilted wick solar stills Yadav and Prasad (1991) investigated the transient behavior of a basin-type solar still analytically and pointed out the effect of energy storage for continuous distillate production. Yadav and Yadav (1998) have also considered a solar still integrated with a tubular solar energy collector and performed a transient analysis for the still performance. Phadatare and Verma (2009) compared glass cover for a plastic solar still with Plexiglas cover in terms of heat transfer coefficients as well as water evaporation and distillate productivity and found that the Plexiglas is gives more productivity as compared with glass cover. Khalifa and Hamood (2009) investigated to show how the productivity is affected by brine depth, using a violet dye experimentally, and correlate them.

## MATERIAL AND METHOD

### Experimental Set Up

In the present work, a Modified Solar Still (MSS) has been designed and fabricated in the Radharaman Institute of Research and Technology, Bhopal, India. Basin and steps of the MSS were painted black. Basin of the MSS was made by GI sheet of 0.5 mm thickness. The basin

area has the dimensions of 100 cm × 76 cm. In the modified solar still fourteen steps were made by GI sheet, toughened glass of dimension 100 × 85 cm is kept at the upper surface of the solar still. The angle of inclination of the toughened glass is 29° as per the location of Bhopal. A channel was fabricated inside the glass cover at the lower surface to collect the distillate. Solar radiation falling on the glass surface are transmitted through the glass cover and absorbed by the black painted steps.

### Instrumentation and Experimental Procedure

The experiments were performed in the month of June 2018 in the college from 9 AM to 5 PM at the Radharaman institute of Research and Technology, Bhopal location (23.26°N, 77.41°E). The experiments were performed in June 2018 in the college from 9 AM to 5 PM. Modified solar still was facing toward south direction, which was found by magnetic compass. A water tank with capacity of 50 liter placed on iron stand of 300 cm height. Brackish water contains 35 gm of salt in 1 liter of water. 10 liters of water was filled in the steps of modified solar still. Solar radiation falling on the glass surface are transmitted through the glass cover and absorbed by the black painted steps. The steps were filled with brackish water through T-section. After some time, due to heat of solar radiation, water on the steps starts evaporation. Continuous spray of cold water was supplied on the secondary glass which was kept between glass cover and steps. Due to spray, the evaporation of water on the glass cover increased. The main purpose of spray was to increase the evaporation rate of the brackish water. Temperature of glass cover, steps water, steps base, vapour and ambient was measured hourly with the help of six channel temperature

Figure 1: Modified Solar Still with Spray System



indicator. The amount of solar radiation falling on the glass cover was measured with the help of radiation Pyranometer. It was placed along the glass inclination surface. Distillate of all three setups was measured by measuring cylinders, which were of 500 ml capacity. The pictorial view of modified solar still is shown in Figure 1.

**RESULTS AND DISCUSSION**

**Variation of Glass Temperature with Distillate of Modified Solar Still**

Figure 2 shows the hourly distillate of the modified solar water desalination system and it is found that, at the start distillate of the system was very low because the glass temperature was low (35 °C). After 11 AM there is an increase in the value of distillate, it reaches the maximum value of 350 ml at 2 PM (glass temperature 52 °C). After 2 PM, distillate value starts decreasing.

**Variation of step and ambient temperature with radiation of a modified solar still**

From the Figure 3, it is concluded that the incident solar radiation gradually increases from morning

Figure 2: Variation of Glass Temperature with Distillate of Modified Solar Still

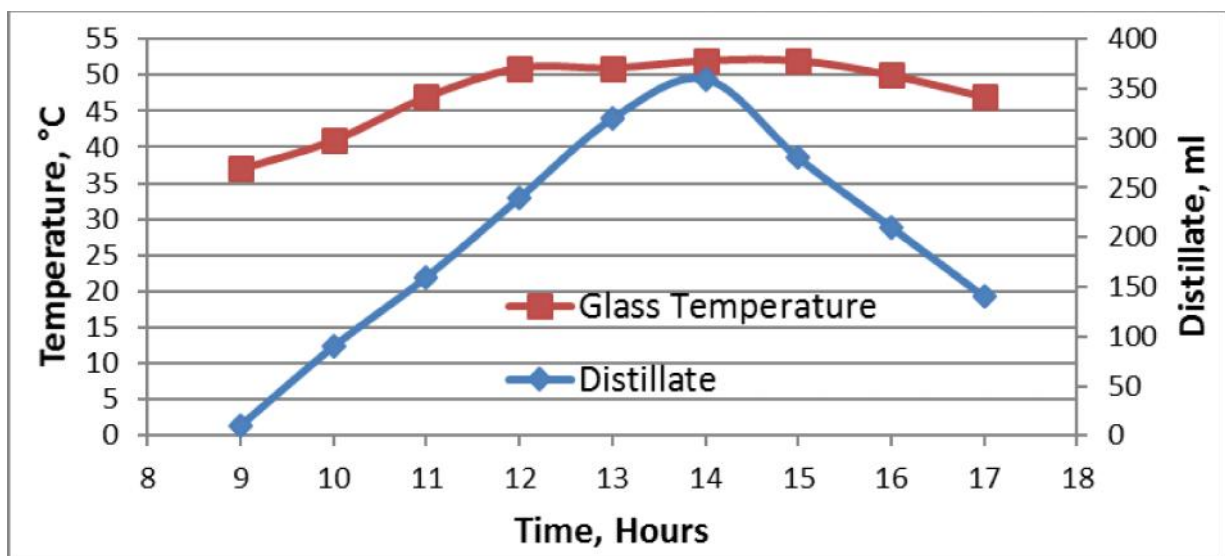
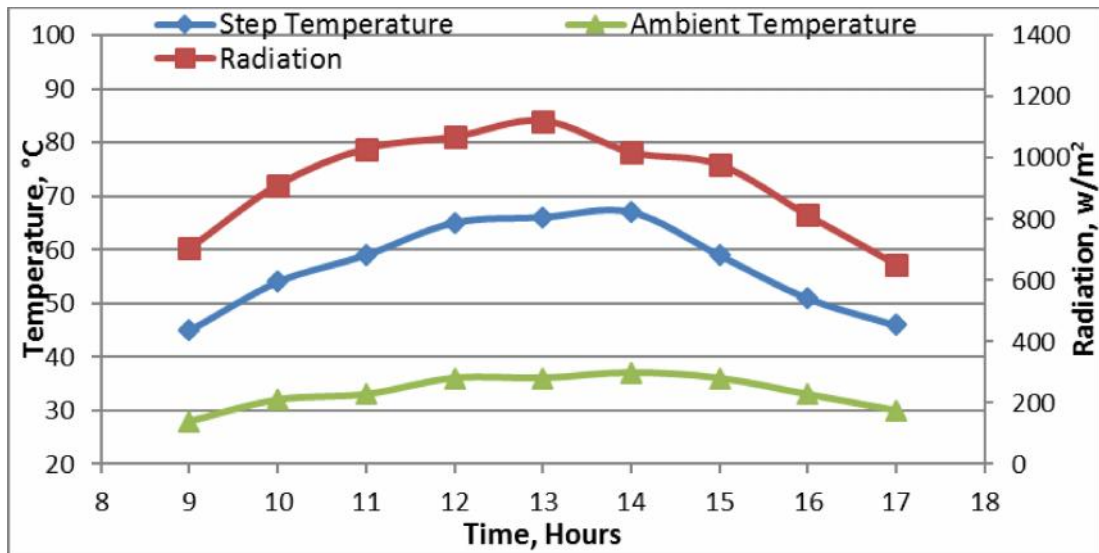


Figure 3: Variation of Step and Ambient Temperature with Radiation of a Modified Solar Still

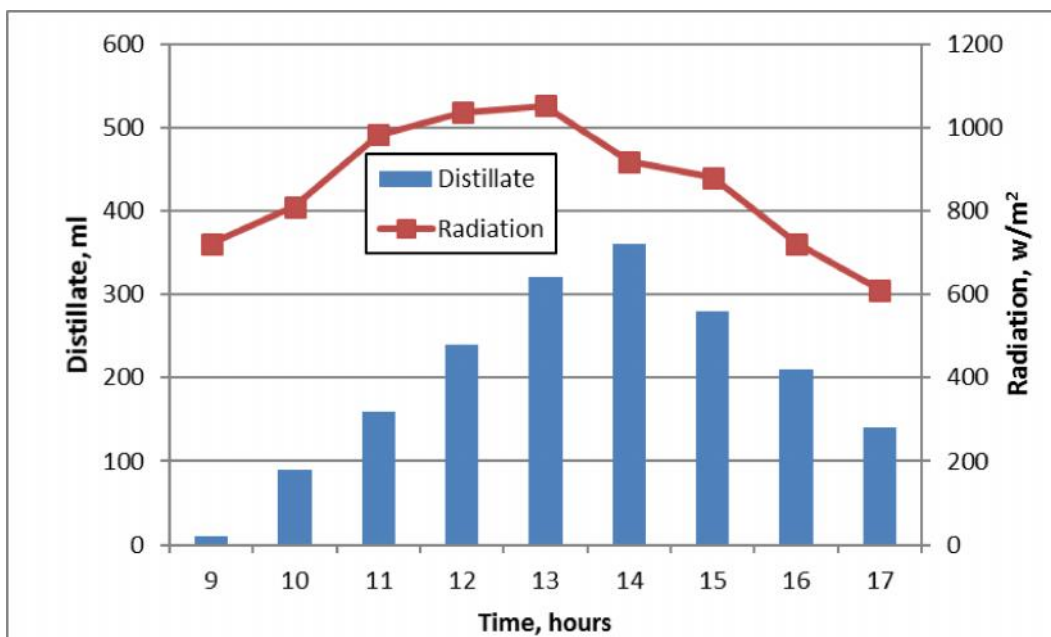


at 9:00 AM and reaches a maximum value of 1121 W/m<sup>2</sup> at 2 PM (solar noon) and after that it starts to decrease with time until 5:00 PM. additionally; the peak ambient temperature of 37 °C is recorded at 2 PM.

**Variation of Hourly Distillate with Radiation**

From the Figure 4, it is concluded that the hourly distillate of the normal day is 2.1 litres. In the morning hours, the distillate is low as solar

Figure 4: Variation of Hourly Distillate with Radiation



radiation is also low. After 11 AM; the value of radiation starts increasing and hence there is sharp increase in the distillate. At 2 PM which is the peak time of the day, the radiation is 1121 W/m<sup>2</sup> and distillate is about 350 ml. After 2 PM there is sharp decrease in distillate value, as radiation also decreases.

## CONCLUSION

In this study, the performance analysis of modified solar still was analysed and various results were found. The comparison of temperatures of the different components, i.e., glass temperature, steps temperature and ambient temperature with radiation as well as distillate was done and the rate of distilled water of the solar still is calculated. The results showed that the maximum value of distillate of the modified solar still is 350 ml at an ambient temperature of 36 °C. It is also found that the hourly productivity of modified solar still varies continuously from 9 AM to 5 PM. Total distillate of the whole day was 2.1 litres.

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