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Original Research Article

EXPERIMENTAL EVALUATION ON A MODIFIED SOLAR STILL WITH PARTIAL STEPS AND ABSORBER MATERIAL

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Abstract: In the present work, a modified solar still has been designed which uses partial steps and absorber material. The performance of the modified solar still (MSS) is compared with conventional solar still (CSS) under the same climatic conditions. The steps and absorber are used to increase time of contact and surface area of water which increase the evaporation rate. The maximum temperature of the steps, absorber plate and CSS basin were found to be 53°C, 61°C and 60°C, respectively. The maximum hourly distillate obtained from the modified solar still was 245 ml, at 1:00 PM and for conventional solar still was 100 ml at 1:00 PM and 2:00 PM. Hence, the productivity of the modified solar still with partial steps and black cotton absorber is higher than that for conventional still nearby 145%. The maximum accumulated distillate from MSS and CSS was obtained 1125 ml and 355 ml, respectively which are 3.16 times or 216% higher than conventional solar still.

Keywords: Stepped solar still, absorber, desalination system, internal reflectors

Introduction: Water is one of the most prime substances responsible for life on earth for plants, animals, human beings and also for the industrial development. Humankind depends on lakes, rivers and underground water to fulfill their basic requirement of fresh water. Due to population explosion and fast industrial development requirement of fresh water has increased extremely. The drinkable water for people around the globe is becoming scarce due to climate change and less rainfall in many areas of the world. The three quarters of the earth surface covered by water, most of the earth's water is found in ocean which is not useable for drinking, industries and growing crops. Therefore, solar desalination system is one of the best options for the separation of saline or brackish water into fresh water using solar energy. It is most useful in remote areas where ample amount of solar energy and saline water are available [1].

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Solar desalination is the process to convert brackish water or saline water into fresh water using solar energy. It consists of a shallow basin filled with saline water for the distillation. The water depth is kept about 5-10 cm. it is covered with inclined transparent glass. Solar radiation is absorbed by the blackened surface of basin after passing through the glass. The heated water evaporates and get condensed which is collected below the glass [1].

Solar stills were the first method which was used on a small scale to convert impure saline water to potable water. In the year 1872 in Las Salines, Chile, CarosWison, a Swedish engineer supplied fresh water to workers at a salt peter and silver mine by the process of solar desalination. The development of solar desalination concern with the use of innovative designs and materials for economical and durable construction to increase the output and in order to reduce the product cost [2].

Literature review: Many research and development has been done to improve the performance of solar still, some developments are discussed blow-

EI-Zahaby *et al.* introduced reciprocating spray feeding system in stepped solar still. The maximum efficiency was found to be 77.3% and productivity 6.355 l/m^2 [3].

Kabeel *et al.* designed and developed steeped solar still and compare with conventional still. They concluded that modified solar still with tray width 120mm and depth 5mm gave 57.3% higher production as compare to then conventional solar still [4].

Rajaseenivasan compare the performed of double slope single basin and double basin solar still. The productivity improves considerably by providing an additional basin in still. The productivity of double basin still is higher than the single basin still by 85% for the same basin condition [5].

Omara *et al.* done comparative study between conventional solar still and stepped solar still by using the internal reflector in stepped solar still. They were found that the stepped solar still with internal reflector has 75% higher productivity than conventional solar still [6].

Ziabry *et al.* studied the cascade solar still and proposed a mathematical model. The experimental data and modal result show that the cascade solar still gave higher fresh water production compare to the initials still unit [7].

EI-Somodony and kabeel investigate the performance of steeped solar still by using water cooling parameter. The most appropriate cooling parameter was found: film thickness 2.5×10^4 to 5.5×10^4 m, volumetric flow rates of water from 4×10^5 to 8.5×10^5 m3/s, and glass cover length from 2 to 2.8 m [8].

Rajaseenivasan used the flat plate collector to increase the inlet temperature of water in single slop single basin solar still. The Flat plate collector basin produced 60% higher distillate as compare to the conventional still for the same basin condition [9].

Sathyamurthy *et al.* used the semicircular through absorber with baffle to increase the contact time of water in basin. They were found that the modified solar still has 16.66% higher production than conventional solar still [10].

Elango and kalidasa introduced a glass as basin material on double slop solar still. The result were compared between the single basin and double basin double slop solar still at insulated and un-insulated condition by varying the depth of water. It is found that double basin still at insulated and un-insulated condition has higher productivity as compare to single basin by 17.38% and8.12%, respectively [11].

Samual *et al.* investigate the performance of inclined solar still by using the different wick material on different absorber plate. They found the highest distillate at water coral fleece with weir mesh absorber plate, which was 4.28l/day [12].

Park *et al.* used the waste heat to increase the performance of hybrid solar still. They were concluded that the productivity of the hybrid solar still was proportional to the heat input [13].

Dashtbanand Tabziri designed and developed a weir type cascade solar still integrated with phase change material (PCM) storage to improve the productivity of the still. 18 kg paraffin wax used as a heat storage material below the absorber plate. The result show that the productivity of the solar still with PCM was 31% higher compare to the still without PCM [14].

EI- Agous studied the cooperation between conventional and stepped solar still with continuous water circulation. He concluded that the productivity of the modified stepped solar still with black absorber was higher than conventional solar still nearby 43% for sea water 48% for salt water, while with black cotton it was 53% more for sea water and 47% more for salt water [15].

Materials and method: The experimental setup of the present study was situated in the premises Radharaman institute of research and technology, Bhopal (23.2599° N, 77.4126° E). The experiments were conducted in December month. The experiments were started at 10:00 AM and ended at 4:00 PM.

The conventional and modified solar stills are designed and constructed. The solar stills frame is fabricated from 0.5 mm galvanized iron sheet which consists of four sidewalls and bottom. The stills are covered with a toughened glass sheet 5 mm thickness (103cm×88cm) placed on G.I. frame. The both experimental setup is kept towards the south direction to receive maximum solar radiation. The still is insulated from the bottom to the side walls with thermocol to reduce the heat loss from the still to ambient.

The modified solar still has the similar construction and geometrical size of the conventional solar still; besides the steps and absorber plate. The horizontal and a vertical length of steps are kept 5 and 3 cm [14]. The inclined plates are covered by black cotton to increase the contact time of water [15]. The basin, steps and absorber plates are coated with black paint to increase its absorptive. The weirs (1 cm) are providing on the vertical side of steps to increase the time spent of saline water on the evaporation surface. The minimum thickness of water on the surface increases the water temperature and evaporation rate.

The temperature of steps, absorber plats, basin water, and ambient air are measured with help of thermocouple indicator. The solar radiation intensity is measured by digital pyranometer. The humidity of both basin water and atmosphere is measured by hygrometer. The distillate was measured with the help of measuring cylinders. All these parameters are measured at hourly.

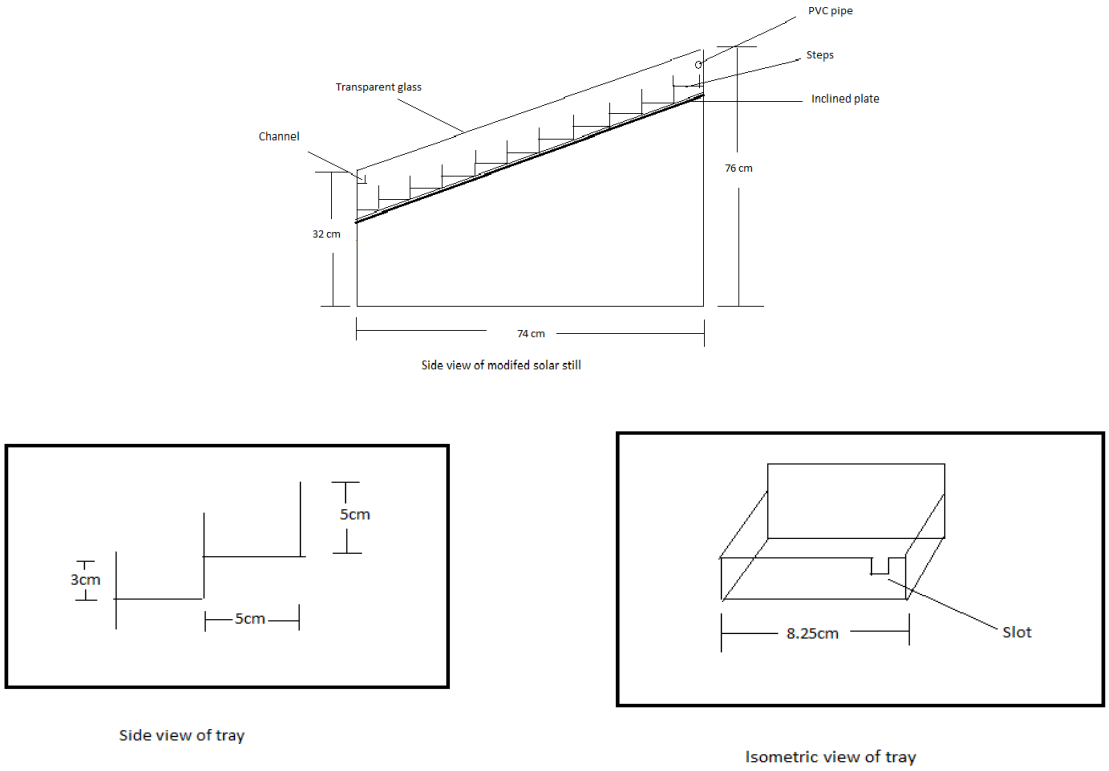

Fig. 1 Schematic diagram of modified solar still

Fig.2. Experimental setup of conventional and modified solar still with instruments

Results and discussion: The performance of the modified solar still was estimated and was compared with that of a conventional solar still under the same meteorological and weather conditions. The temperature variation of ambient air, CSS basin, MSS basin, MSS steps and MSS absorber plate with time is shown in fig. 3. The maximum temperature on steps and inclined absorber plates in modified solar still was found to be 61°C and 60°C, respectively at 1:00 pm while the maximum temperature of CSS basin was 53°C.The variation of ambient temperature is between 24 to 29°C. Solar radiation received during the study is between 910 and 1200 W/m^2.

Fig. 4 shows variations of hourly distillate of modified and conventional solar still with time, from 10:00 AM to 4:00 PM. the hourly productivity of modified solar still is higher than the conventional solar still. The maximum hourly distillate obtained from the modified solar still was 245 ml, at 1:00 PM while for conventional solar still was 100 ml at 1:00 PM and 2:00 PM Hence, the productivity of the modified solar still with partial steps and black cotton absorber is higher than the conventional still approximately by 145%.

Fig. 5 shows variations of accumulated distillate of modified and conventional solar still with time. It is found that the amount of accumulated distillate for modified solar still is higher than that of conventional still at all time. The maximum accumulated distillate from MSS and CSS was obtained 1125 ml and 355 ml, respectively which are 3.16 times or 216% higher.

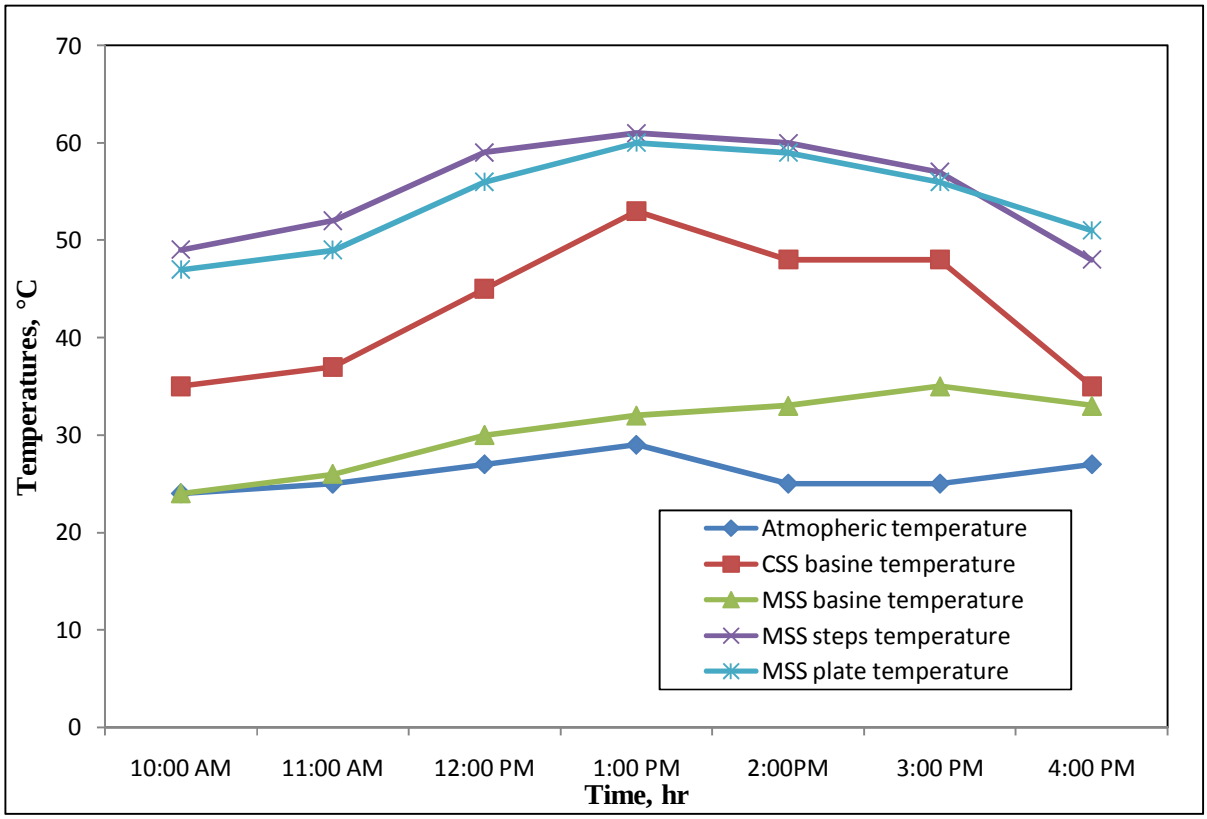

Fig.3. Variation of temperatures w.r.t. time

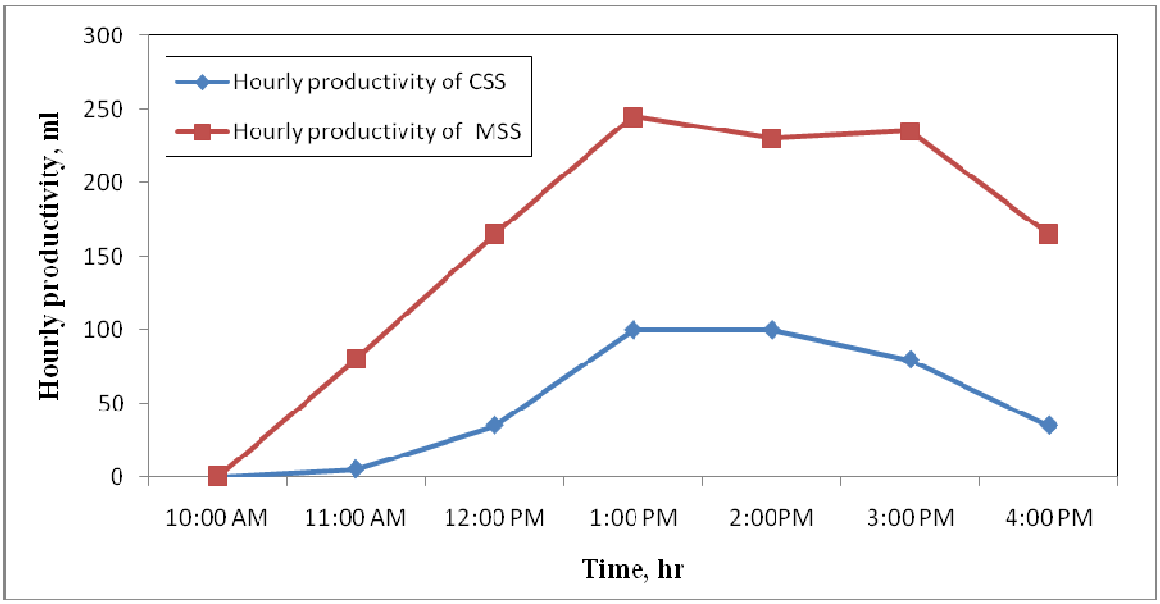

Fig.4. Variation of hourly productivity of MSS and CSS w.r.t. time

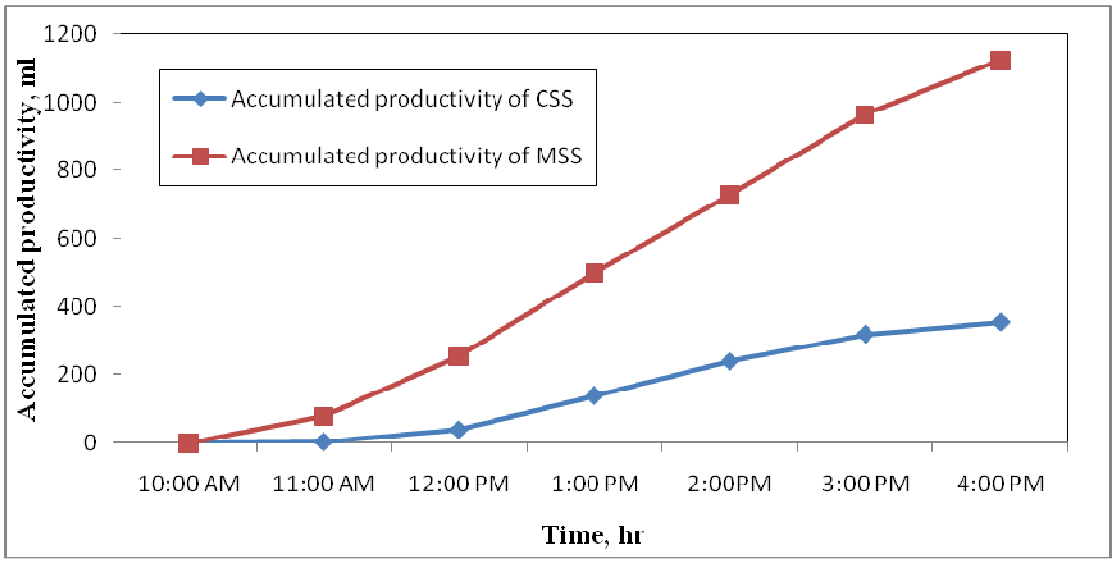

Fig.5. Variation of accumulated productivity of MSS and CSS w.r.t. time

Conclusions: In this work, the performance of the modified solar still using partial steps and partial cotton absorber has been experimentally investigated. The effects of providing partial steps and partial inclined absorber on the solar still performance have been considered. On the basis of experimental data, the following conclusions can be drawn.

1) The maximum temperature of the steps and absorber plate was found 61°C and 60°C, respectively at 1:00 PM while the maximum temperature of CSS basin was 53°C at 1:00 PM.
2) Maximum hourly productivity of the modified solar still is higher than the conventional solar still by 145%
3) Maximum accumulated productivity of the modified solar still is higher than the conventional solar still by 216%.
4) Using a weir in vertical side of steps increase the equal distribution of water on

evaporative surface which leads the evaporation rate.

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