ENHANCING THE PERFORMANCE OF SINGLE SLOPE SOLAR STILL USING JUTE CLOTH KNITED WITH SAND HEAT ENERGY STORAGE

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ABSTRACT

One of the best methods in improving the yield of fresh water from the solar still is incorporating sensible heat energy storage materials. This work aims at improving the yield of fresh water from the single slope solar still using sensible heat energy storage knitted with jute cloth on the entire surface of the material. Experimental investigations were carried out in the single slope solar still with and without jute cloth knitted with the material and for validation of results the solar still without any material is tested for the same experimental condition. Experiments were carried out with different water depth inside the basin. The results show that the yield of fresh water is completely depends on the parameters such as mass of sensible energy material and depth of water maintained inside the basin. The yield of fresh water under least water depth (d_w=0.02m) from the solar still with and without jute cloth knitted with sensible heat storage materials were found to be 5.9 and 5 kg/m^2, respectively.

Keywords: Yield, water depth, jute cloth, sensible heat, material

1 INTRODUCTION

The serious problem faced by the world in this century is to provide adequate supplies of fresh water. This fresh water is obtained by converting saline water. In order to convert this saline water to useable water various methods are adopted. These methods include Multi effect evaporation, multi stage flash distillation, thin film distillation, reverse osmosis, electrodialysis and it is observed that these methods are energy intensive and operations costs are high. So, direct use of solar energy is employed and this represents promising option for eliminating the major operation cost required in each cases of above methods. The solar desalination is the most attractive and simple technique among other methods and is especially suited to small scale units and locations where solar radiation is of abundance. The increase in population, economic development in addition to global warming leads to worldwide imbalance between supply and demand of fresh water. It is known fact that three-fourth of the surface of the earth is water [1-17].

Phadatare and Verma [18] analysed how water depth influence the single basin solar still. Their reports states that a variation in water depth decreases the yield by 12% and the minimum water depth of d_w=0.02m. The average basin water temperature is about 50 °C and a temperature decrease is about 3% while increase in depth is varied.

Yadav and Tiwari [19] investigated a double slope solar still theoretically and experimentally. Results shows that there is a 45% reduction in the effect of shadow from the side walls compared to the single slope solar still. The yield from the still in increased from 1.7kg/m^2 to 2.4kg/m^2. It is reported that the temperature of the water initially filled in the lower basin drives the evaporation in the upper basin of the still. When a raise in temperature was implemented, a higher yield (almost 25%) was collected compared to yield collected during the initial temperature. On successive periods, the drop in yield is 28% due to its mass. The performance of solar still is higher during off shine period, because of the release of higher energy storage by saline water to regain its thermal equilibrium.

In this study, the use of sensible heat energy storage and use of jute cloth around the sensible heat storage material is experimentally investigated on improving the performance of single slope solar still. Similarly, the effect of water mass (depth) is experimentally investigated on the effective capillary rise of water in the wick material.

2 EXPERIMENTAL SETUP

The experimental setup consists of a basin with side height of 0.3m on one side and 0.4 m on other side with an inclination angle of 13^o to keep the glass in an inclined position. Provisions were provided to feed the water into the basin and drain valves are provided the bottom of the basin to take the contaminated water and for cleaning purpose. The fresh water condensed in the inner surface of the glass is glided to the distillate collector kept at the end of the glass. Due to the increase in the temperature of water inside the basin and partial pressure developed vapor is formed in between the water and glass surface and thus condenses. The area of the basin is fabricated with 1m x 0.5m and area of the glass is almost the same as the basin. The experimental photograph of the modified solar still is shown in Fig.1 and the schematic diagram of the experimental test rig is shown in Fig. 2. The detailed uncertainty analysis and observed error is shown in Table. 1.

Figure 1. Experimental photograph of modified solar still with jute cloth knitted to sensible heat energy storage

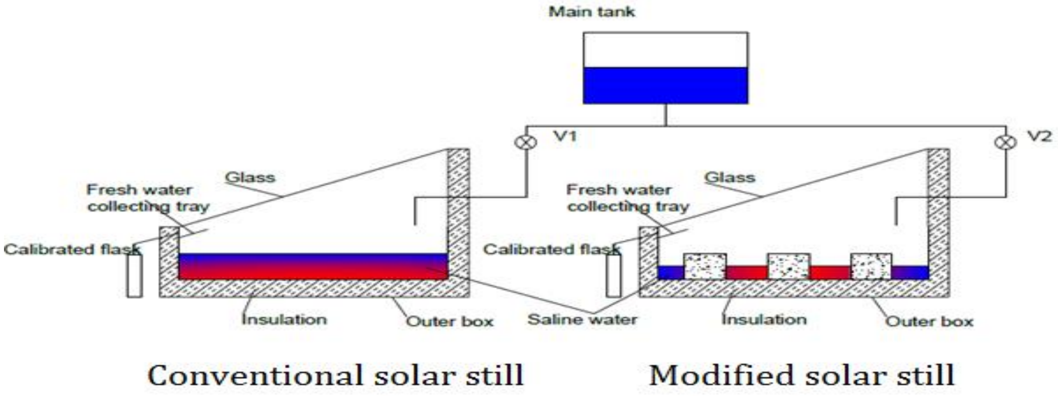

Figure Schematic diagram of conventional and modified solar still with cement coated red bricks

Table. 1Uncertainty, standard uncertainty, error and measuring range of instruments

Instrument	Accuracy	Range	Error (%)	Observed error (%)	Standard Uncertainty
Thermocouple	±1°C	0-100°C	0.25	1.2	±0.57 °C
Solar power meter	±1W/m^2	0-2500 W/m^2	2.5	3.1	±0.57 W/m^2
Anemometer	±0.1m/s	0-45 m/s	10	6.8	±0.05 m/s
Beaker	±10mL	0-1000mL	10	8.3	±5.77 mL

3 RESULTS AND DISCUSSIONS

The effect of water mass on average water temperature using different technique is plotted in Fig. 3. It can be observed that the increase in water mass decreases the average water temperature by 1°C using sensible heat energy storage material as compared to solar still with modified sensible heat energy storage. Due to continuous evaporation from the surface of water and effective capillary rise by the wick material, the average water temperature increases. Similarly, the average water temperature increases to about 42°C in the case of higher water mass inside the conventional basin as it is due to the effect of energy storage by saline water. The average water temperature using sand and wick material is almost having similar trend and higher to about 25% as compared to conventional basin.

The average yield from conventional and modified solar still under variation of water mass inside the basin is shown in Fig 4. It is observed that the average yield from all basin condition decrease the average yield from the solar still in a linear manner. The maximum yield obtained from the solar still at minimum water mass is found as 0.075, 0.15 and 0.18 kg for conventional basin, jute knitted sand heat energy storage and solar still with sand heat energy storage respectively. It is also observed that the effective increase in temperature of water inside increase the average yield from modified solar still. While comparing the accumulated yield from different configuration of materials inside the basin, the yield with jute knitted sand heat energy storage produced maximum yield of 2.85 kg (5.9 kg/m^2) and the yield from sensible heat energy storage is found as 2.75 kg (5.5 kg/m^2) at minimum water mass of 10 kg inside the basin (Fig. 5). The yield of fresh water using jute knitted sensible heat energy storage and sensible heat energy storage is increased by 56.14 and 54.54 % than conventional solar still.

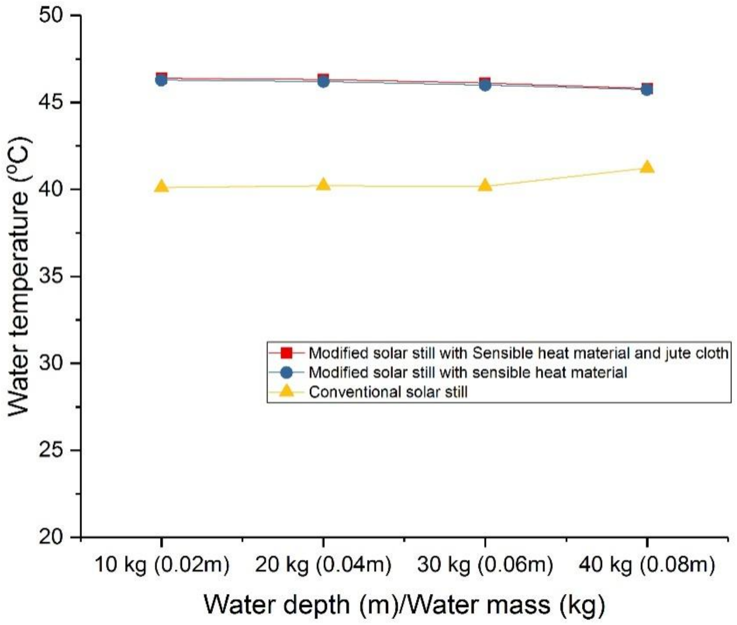

Figure3. Variation of average water temperature of conventional and modified solar still

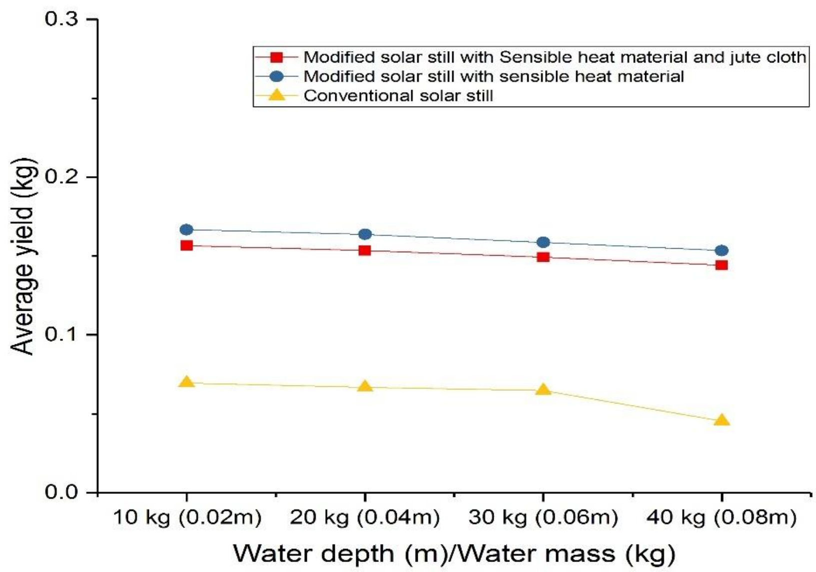

Figure 4. Variation of average yield from conventional and modified solar still

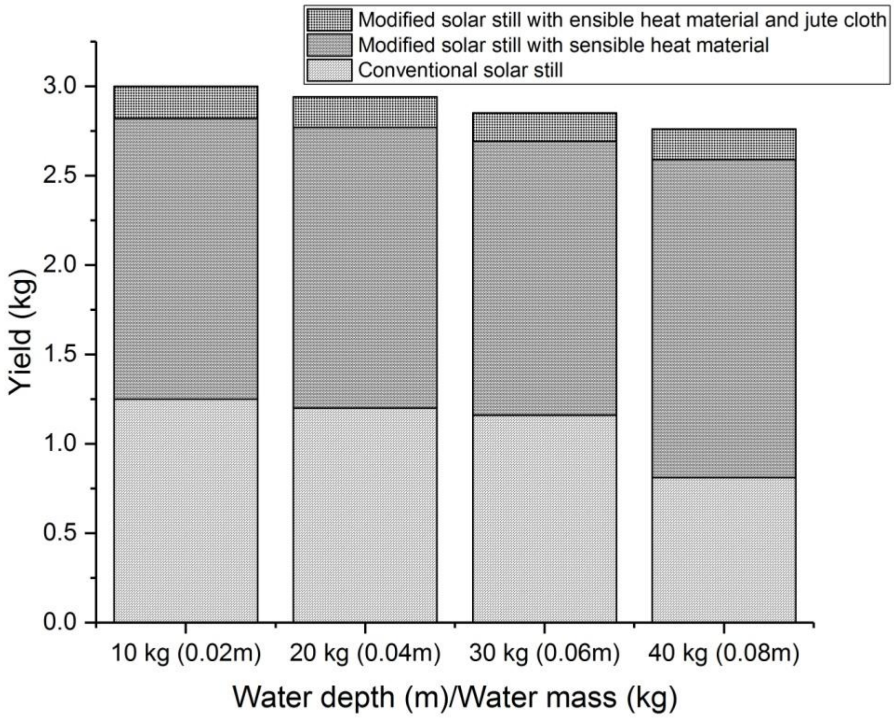

Figure 5. Variation of yield from solar still with and without energy storage material and jute cloth

4 CONCLUSIONS

Experimental investigations were carried out in the single slope solar still with and without jute cloth knitted with the material and for validation of results the solar still without any material is tested for the same experimental condition. From the experimental results the following conclusions are arrived at:-

- The yield of fresh water is completely depending on the parameters such as mass of sensible energy material and depth of water maintained inside the basin.
- The average water temperature in the case of sensible heat energy storage as well as jute cloth knitted sensible heat storage were found to be similarand 25% higher as compared to conventional solar still.
- The yield of fresh water under least water depth (d_w=0.02m) from the solar still with and without jute cloth knitted with sensible heat storage materials were found to be 5.9 and 5 kg/m^2 respectively

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