EXERGY ANALYSIS OF SINGLE SLOPE SOLAR STILL WITH LOW COST ENERGY STORAGE MATERIAL

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ABSTRACT

This paper communicates the exergy analysis of conventional solar still with and without modification (energy storage material). Experiments were carried out in different water mass maintained inside the basin under constant mass of energy storage material. Detailed exergy evaporation and efficiency investigations were carried out using different water mass. Results show that the increase in water mass decrease the exergy efficiency during sunshine hours and there is an increase during offshine and low radiation period for higher water mass. Results also show that the maximum exergy efficiency of 20 and 9% for higher water mass (m_w=50 kg) in conventional and modified solar still respectively.

Keywords: Energy storage, Solar still, Improved yield, Water mass

1 INTRODUCTION

Water is one of the important phenomenon for the survival of humans [1-2]. Due to lack of drinking water several methods are employed to convert waste water into potable water. Among which solar still are appeared to be the cheapest technique for converting brackish water into safer drinking water. Due to its lower yield several methods are employed to improve the yield of fresh water. On economic aspect the use of flat plate collectors, parabolic collectors are higher in their cost of initial investment which is unaffordable for people [3]. Energy storage is the best technique used globally to reduce the waste and increase the efficiency [4]. Storage of energy can be classified into sensible heat and latent heat.

K.K. Murugavel et al [5-8] investigated a double slope solar still with different wick material [5] and different energy storage material [6] at minimum water mass. The results show that the use of rectangular aluminium blocks with cotton cloth produced the maximum yield for 2 m^2 area. Whereas, the yield of fresh water using coir mate, sponge sheet and waste cotton pieces without aluminium fins produced an average yield of 2.8 kg/day [5]. The use of different energy storage materials in the basin the yield was higher in the case of ¾” quartz rock [6] for the same area of basin.

Rajaseenivasan et al [9] investigated a double basin and single basin solar still with different energy storage material and wick material. The results show that the use of mild steel pieces inside the basin increases the yield by 12.56 % than using clay pots facing up respectively in single basin solar still whereas in a double basin solar still the yield is increased by 14.23%.

Alaudeen et al [10] investigated a stepped solar still with different energy storage material with glass cubes. The results show that glass cubes with dry salt increased the yield of fresh water during the sunshine hours while the night time yield is found to be 0.5 kg/m^2. Also, the gain in fresh water yield is found as 149.5% than solar still without any modifications. While analyzing the economic aspect the payback period of solar still with dry salt is 404 days which is quicker. Sathyamurthy et al [11] experimentally investigated a single slope solar still with PCM in between evaporating and condensing chamber. Similarly sathyamurthy et al [12-16] investigated a triangular pyramid solar still with and without phase change material. Results show that the efficiency of solar still was increased by 35% than solar still without PCM storage.

In this work a novel method is employed in improving the yield of fresh water from single slope solar still with cement coated red bricks with specified dimensions.

2 EXPERIMENTAL SETUP

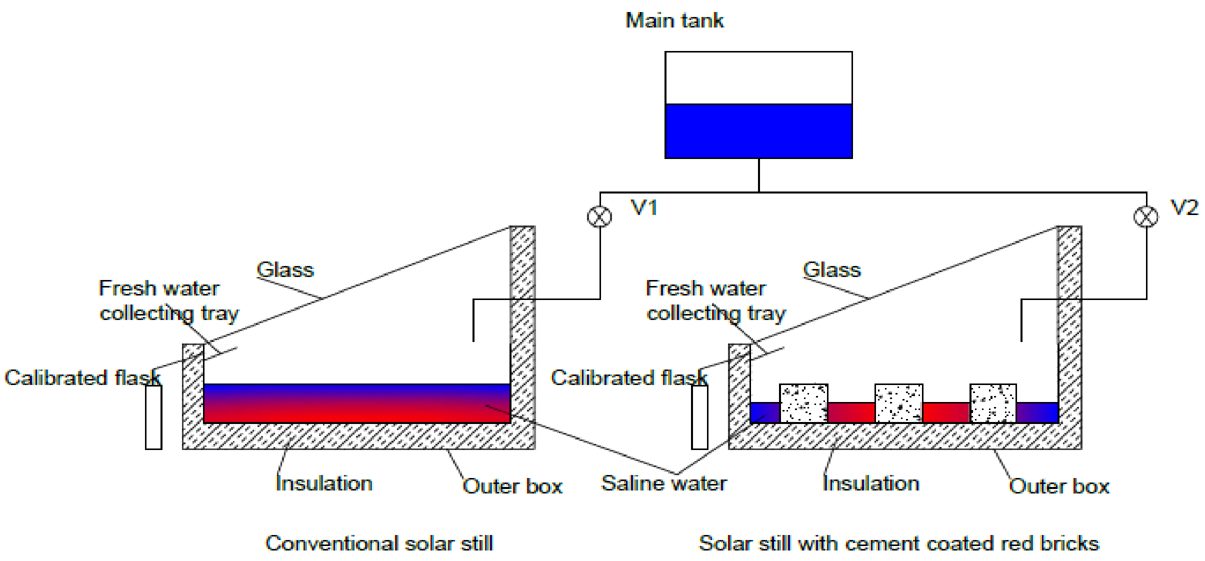

Figure 1. Schematic diagram of conventional and modified solar still with cement coated red bricks

Fig. 1 and 2 shows the schematic diagram and experimental photograph of a single slope solar still with low cost energy storage. It consists of a basin with 1 m^2 area and filled with water and cement coated red bricks. Saline water is stored in the storage tank and fed into the basin using flexible hose piping with insulation and flow control valve V1 and V2 are provided. To maintain the constant water mass inside the basin, fresh saline water is fed into it after evaporation from the surface. The surface area of water is increased by keeping defined dimensions of energy storage material. K.K. Murugavel [6] used a different approach on energy storage material with indefinite shapes in basin. Each bricks are sieved with a dimension of 0.1 x 0.1 x 0.1 m and coated with cement layer of 0.05 m is coated over it. Totally 12 bricks were used during the experiments whereas, the exposure water area is 0.84m^2. The water mass used during the experiments is 20 kg and it appeared to be the optimized mass from the literature survey. Similarly, the water mass inside the basin is increased from 20 to 50 kg to study the performance of the present system to optimize the water mass. Experiments are conducted on a domestic house hold of Chennai, India to study the feasibility of its use for commercialization. Temperature of various elements in solar still are measured using PT-100 (RTD) sensor with an accuracy of ±1% and environmental parameters such as solar intensity and wind velocity are measured using TES-1333R solar meter and AM4836 cup type anemometer respectively. Experiments are conducted from 7 AM to 12 AM with bright and sunny condition during the sunshine hours.

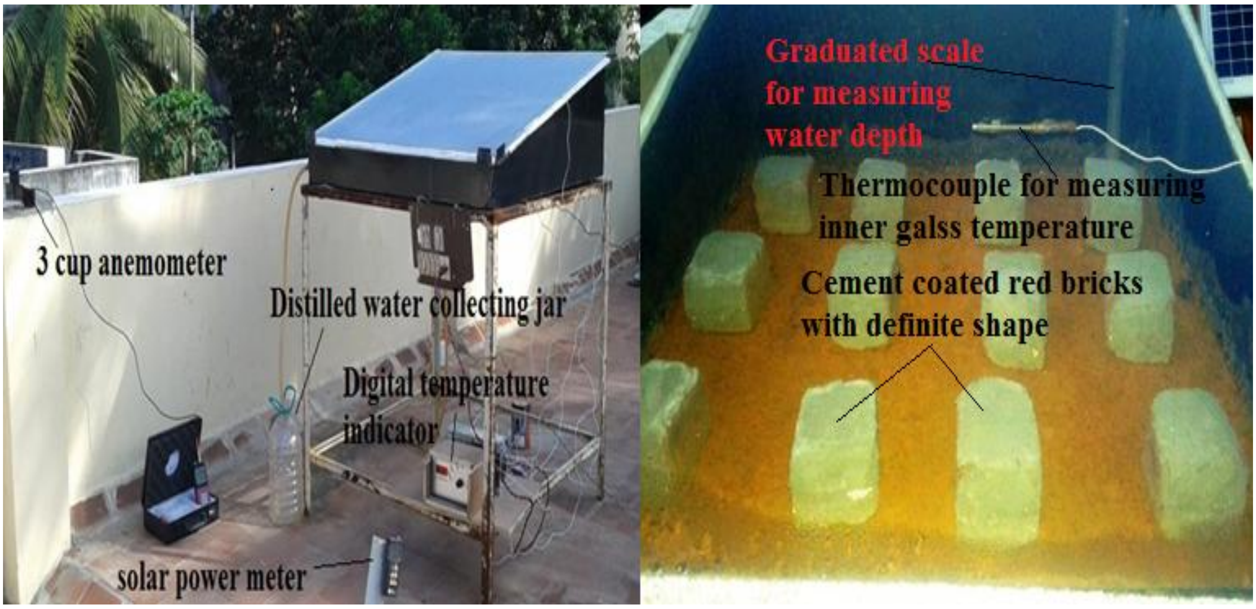

Figure 2 Experimental photograph of the modified solar still with instrumentations used

3 RESULTS AND DISCUSSIONS

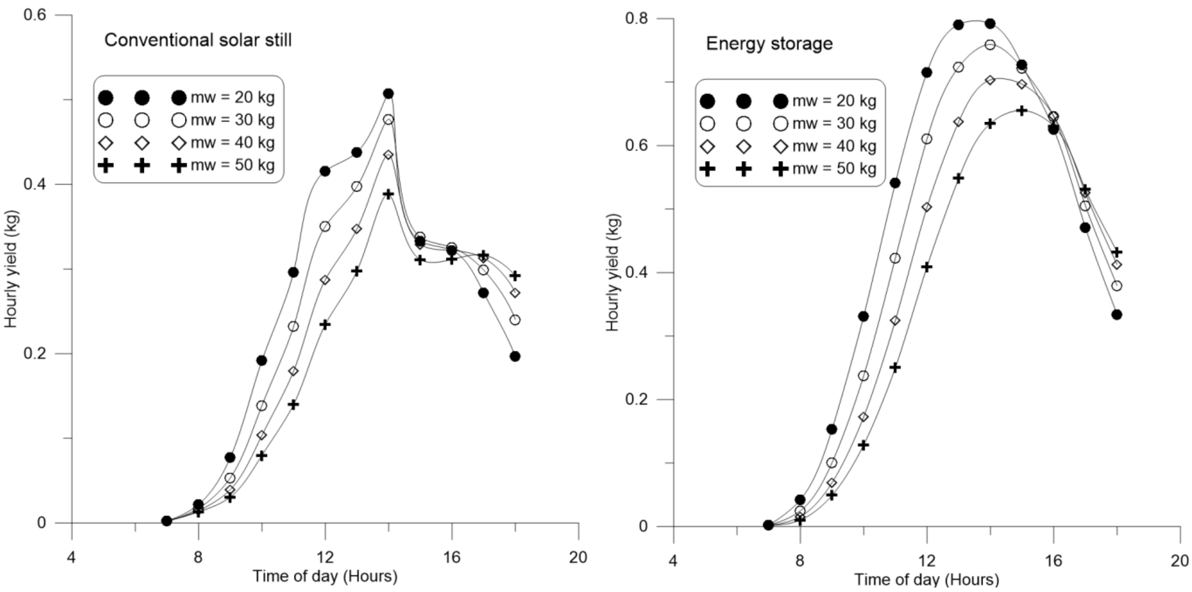

Figure 3. Variations in yield from conventional and modified solar still

Fig. 3 shows the hourly variation of yield from the solar still with and without modification. The maximum yield from the solar still with least water depth and mass of energy material are found as 0.8 kg/hr and this is higher than solar still without modification by 30%. Due to the lower heat capacity of energy material the water temperature inside the basin is higher in the case of least mass of energy storage material. The optimum water mass of energy storage material inside the basin is found as 20 kg. The maximum yield from the solar still with energy material is found as 3.34 kg for 8-hour operation. The total yield from the solar still increases by 40.41 % than conventional solar still without energy storage.

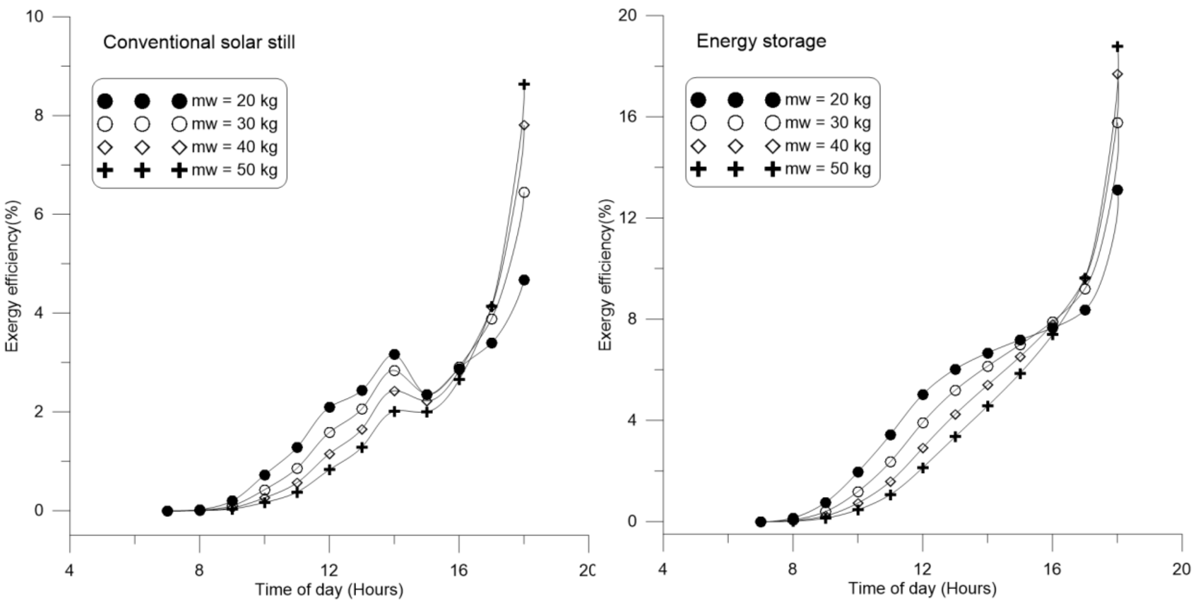

Figure 4. Variations in exergy efficiency of conventional and modified solar still

Fig. 4 shows the variations in exergy efficiency of conventional and modified solar still. The maximum exergy efficiency is found as 20 % with the maximum water mass and least mass of energy material inside the basin. The maximum exergy efficiency from conventional solar still at the same equivalent water mass of 20 kg is found as 5%. With possible increase in the water mass, the exergy efficiency from the solar still increases as there is an equivalent amount of energy stored by higher water mass which increases the yield and exergy from solar still.

4 CONCLUSIONS

From the experimental analysis the following conclusions arrive:-

- The yield of fresh water depends on the material and mass of material used in the basin. It is observed that the increase in the mass of energy material decreases the yield of fresh water by 12%.
- The optimum mass of energy storage material inside the basin is found as 20 kg.
- The maximum yield from the solar still with energy material is found as 3.34 kg for 8-hour operation. The total yield from the solar still increases by 40.41 % than conventional solar still without energy storage.
- The maximum exergy efficiency is found as 20 % with the maximum water mass and least mass of energy material inside the basin.
- The maximum exergy efficiency from conventional solar still at the same equivalent water mass of 20 kg is found as 5%. With possible increase in the water mass, the exergy efficiency from the solar still increases as there is an equivalent amount of energy stored by higher water mass which increases the yield and exergy from solar still.

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