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An experimental study on single basin double slope glass active solar still with different depths of water

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ABSTRACT

In this work, effect of water depth on the single basin and double slope glass active solar still was studied. A solar collector is connected with solar still to convert the passive still into active. The set up was fabricated from a transparent glass .The thickness of the side glasses and bottom glasses are 8 mm and the upper slope glasses are 3.5 mm. All sides are made with same material. The bottom surface was coated with black coating. The solar still was insulated so that the heat dissipation could not take place to the surrounding. The length of the still is 1m and width is 0.5 m and depth of 10 cm was given and at this depth a slope of 15^0 was given. A flat plate solar collector is also added which is fabricated through Galvanised iron sheet whose thickness was 2.5 mm. It is in rectangular shape whose dimensions are (30cm x 15cm x 10cm). A copper tube is circulated with snake shape through which water is circulated. The study covers the influence of water depth of 1cm, 2cm and 3 cm with and without coal in the still productivity. The results stated that distilled water collection is highest for lower depth of 1 cm with and without coal. Even among lower depth, water with coal observed 21.9% increases in productivity in comparison with without coal.

1. Introduction

Need of pure water is important in day-to-day life. Solar desalination represents the most prominent and economical method especially when used in villages areas where sunshine is abundant. It is an eco friendly technology which can open up new purified water sources and contributes efficiently in the sustainable development of villages and urban areas as well. Generally the solar still are selected due to their simplicity in construction. No need of regular maintenance and no need of skilled person for operation. So, little operational and maintenance cost.

Hossen et al. [1] studied various water depth on the still productivity. Ali. F.Muftah and M.A.Alghoul[2] reviewed that water depth is an important design factor in the distillation process.T. Rajaseenivasan and K. Kalidasa Murugavel[3] worked on single and double basin solar still and showed that productivity is varied by various water depth. Hussain and Rahim [4] stated that still can produce yield not only in a day ,but also in the night time. Zeinab et al. [5] reviewed different methods to improve the productivity in solar still. P.V. Kumar [6-7] reviewed different solar still designs in terms of passive and active solar stills. A. K. Kaviti [8] presented the detailed review on inclined solar stills to enhance the productivity.

For the improving water productivity, various experimental and numerical investigations have been done in the past like utilizing the latent heat of condensation [9], addition of solar collectors [10] and utilizing energy storages [11]. In this study, a flat plat solar collector is coupled with a passive solar still. The main purpose of solar collector is to preheat the water which is entered the solar still. The still out let is connected with the inlet of solar collector and its outlet with the inlet of solar still. The water is circulated through copper tube, due to high thermal conductivity of copper tube it absorb larger sun radiation and dissipate to water through which water start evaporating. This vaporised water is circulated in to solar still.

In this work, effect of water depths in the still productivity is studied for a depth of 1 cm, 2 cm, and 3 cm with and without coal. Temperature variation of still water, inner glass, outer glass, air level and black coating was noted for each case. Hourly and Cumulative productivity is measured.

2. System description

A single basin double slope solar still has been fabricated with transparent glass as shown in Fig.1. The overall size of the solar still is 1m length, 0.5m width and 0.01 m depth. The top is covered with two glasses of thickness 3.5 mm inclined at 15^0 on both sides. The outer surfaces are covered with thermocol insulation. The condensed water is collected in the V-shaped drainage provided below the glass lower edge on both sides. The condensate collected on both side of the still is continuously drained through flexible hose and stored in the bottle. A hole in the basin side wall allowed inserting the thermo-couples for the measurement of the basin water, still, condensate temperature, and water level temperature. The hole is closed with insulating material to avoid the heat and vapour loss. Another hole is provided for water inlet. A small tube is inserted through this hole to supply saline water continuously to the basin from storage tank through a flow regulator. And at

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its outlet solar collector inlet is connected and at its outlet, still in let port is connected, thus the mass of water in the basin always kept constant. Observations are taken for 8 hrs duration starting from 10 a.m.to 5 p.m. The temperature of the atmosphere, basin water and the condensate are noted for every 1hr. The temperature reading and condensate water collected on both side of the still are also noted.

Fig 1. Experiment Setup of double slope glass active solar still

3. Experimental procedure

Experiments on double slope solar still with various depth of water without addition of coal such as 1 cm, 2 cm and 3 cm was done on 03/10/2015, 07/10/2015 and 08/10/2015 respectively. Also solar still with addition of coal at various depth of water such as 1 cm, 2 cm and 3 cm was done on 14/10/2015, 15/10/2015 and 16/10/2015 respectively. It was done for 8 hours in a day from 10:00 am to 05:00 pm. Solar intensity variation is uncertain for each day and experiment was done on these days where the sun was fair so that the results made worthy of comparison. Solar still was placed in glass facing East-West direction. The various measured parameters such as glass temperature, water temperature, absorber temperature; vapour temperature was measured by using K-type thermocouples through temperature indicator device. All the parameters and amount of condensate production was noted for every one hour.

4. Results and discussions

4.1 The effect of depth of water without coal

Fig. 2 illustrates the variation in temperatures at different positions in the still when 1 cm depth of water present in the still. It is clear that at all temperatures are increasing till 1pm and attained maximum values of water temperature (T-water), inner glass temperature (T-inner glass), black coating surface temperature (T-black surface) at 1pm. Then values start decreasing till the end of measurement. Similar observations were found in Fig.3 also. In Fig. 4, first all temperatures start decreased till 1 pm then they remain almost steady till the end of measurements. On the third day, sun started with high intensity and there was sudden change in the climate for first half day.

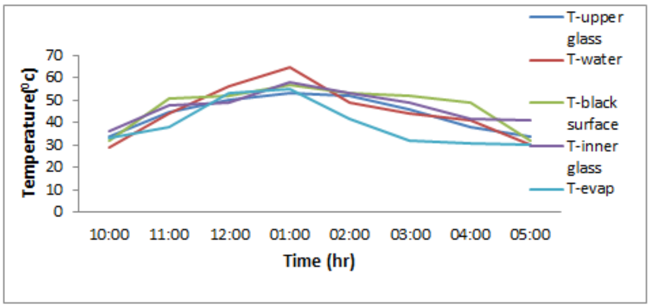

Fig 2.Variation of temperature with time when water level 1 cm without adding coal.

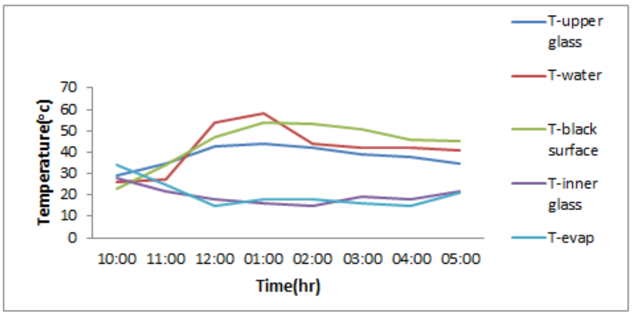

Fig 3.Variation of temperature with time when water level 2 cm without adding coal.

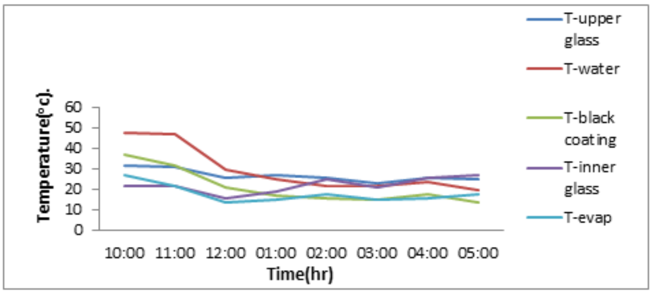

Fig 4.Variation of temperature with time when water level 3 cm without adding coal.

4.2 The effect of depth of water with coal

In this case coal is added with the water at different water levels such 1 cm, 2 cm and 3 cm respectively and we analyse the variation of temperature with respect to time as shown in Fig. 5-7.

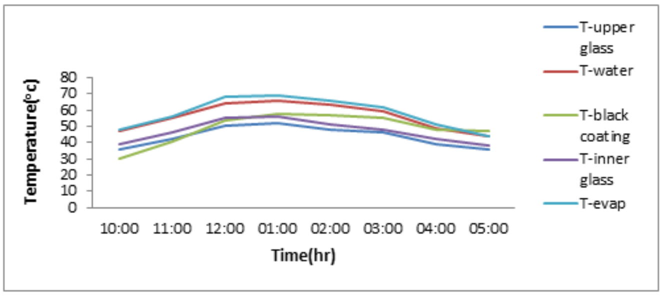

Fig 5.Variation of temperature with time when water level 1 cm with adding coal.

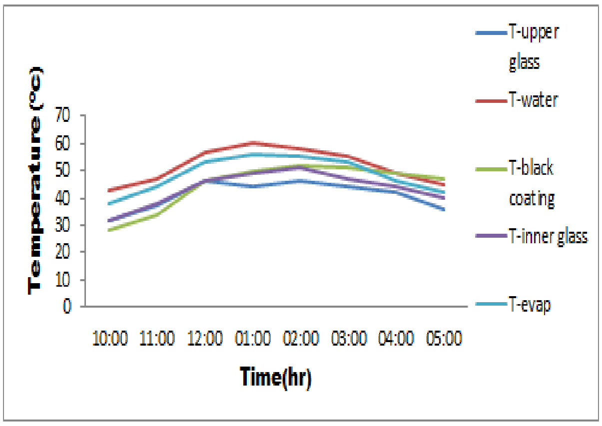

Fig 6. Variation of temperature with time when water level 2 cm with adding coal.

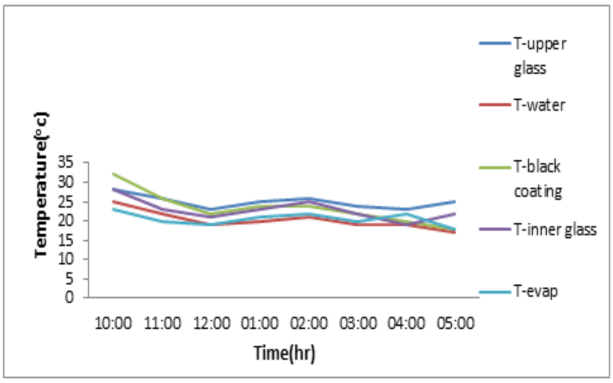

Fig 7. Variation of temperature with time when water level 3 cm with adding coal.

Fig.5, illustrates the effect of water with coal on various temperatures. It was observed that when the water level is 1 cm the temperature initially increases up to 1 p.m. and after that it decreased. From, Fig.6, it is clear that all temperatures increased up to 1 p.m. but relatively less in comparison to 1 cm. But in Fig.7, temperature initially decreased then increased again decreased and increased alternately with respect to time. Changes of measured temperature of Evaporation, is always higher than the other temperatures and upper glass surface temperature is always less than the other measured values. Each parameter attained maximum value at the peak time around 1.00 pm.

4.3 Variation of productivity with every one hour

The variation of productivity with every one hour without adding coal and adding coal at different water level as shown in Fig.8 and Fig.9 respectively.

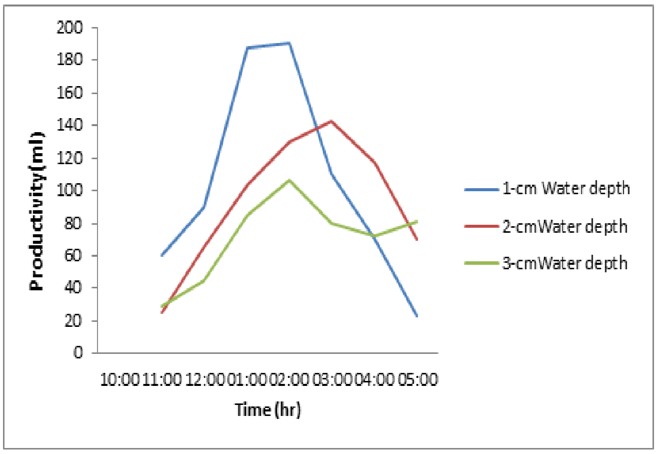

Fig 8. Productivity of water with time(without coal)

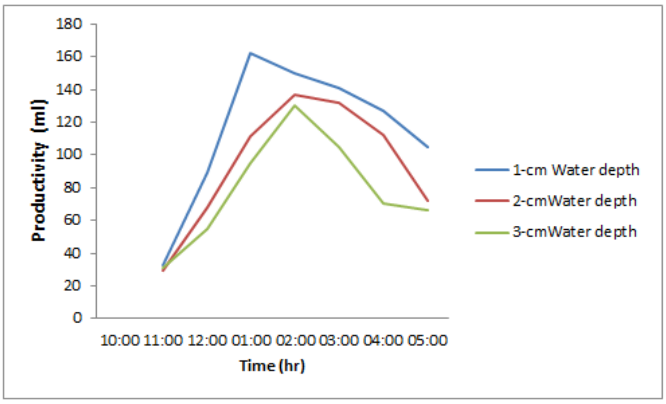

Fig 9. Productivity of water with time (with coal)

It is clear from the graph that hourly production was higher for lower water depth. Hourly production should be compared with the day temperature and it can be deduced that the condensate production is proportional to the temperature available. At the starting hours, the hourly production is increases up to 1 pm. and after that decreases. At higher depth the productivity is lower. But it is found that the productivity is higher with addition of coal as comparison to without adding coal.

4.4 Comparison of Cumulative collections for various depths

Cumulative production is the total amount of added hourly production for a period of 8 hours Calculated from the Fig.10 (without adding coal) and Fig.11 (with adding coal)

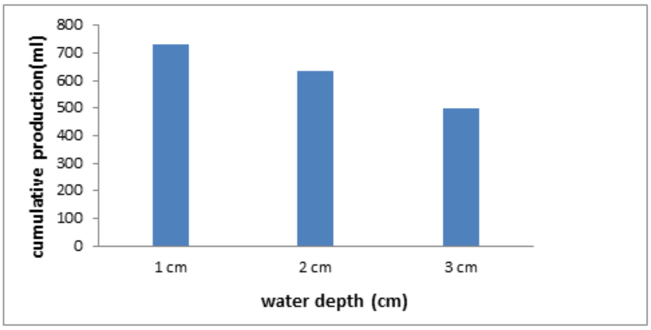

Fig 10. Cumulative productivity for various water depths without adding coal.

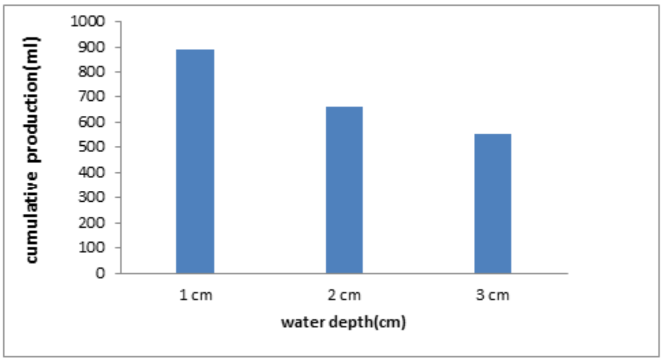

Fig 11. Cumulative productivity for various water depths with addition of coal.

It is clear from the above Figures that total productivity is higher at 1 cm and lesser at 3 cm for the period of 8 hours (from 10:00 am to 5:00 pm).Variations in the cumulative production should compared with the different water depth in the still. Rate of evaporation varies due to variation in the amount of water in the still and due to this; cumulative production becomes different in each case. It is also observed that cumulative production is higher with the addition of coal as comparison to without addition of coal at different water depth.

5. Conclusion

In this work a double slope single basin active type still with basin area of 0.5 m^2(100cm x 50cm) and flat plate solar collector area of 0.045 m^2 (30 cm x 15 cm) are fabricated and used . Performance of the still is compared for different depths of water without coal and with coal. It is found that the distilled water productivity is increased by 21.9% by addition of coal in the water. It is also concluded that with the increase in depth of water, distilled water collection decreases. So, best distillate is observed at 1 cm depth of water.

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