International Journal of Innovations in Engineering and Education
www.ijiee.com Volume-01, Issue-01

Analysis of concentrator type solar still with various materials

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Abstract: In this analysis a single basin type solar along with concentrator type solar still was fabricated and tested for desalination of water with various water depths, sensible heat, latent heat and porous materials operated almost on same heat inputs. A concentrator with heat exchanger is designed in a conventional type solar still to act as temperature booster.. The collector tray was of dimension 0.9 m^2 and 4 mm thick G.I. Sheet was painted black and was attached with heat exchanger pipe. The inclination of the glass is 30°. Different water depths of 2cm, 3cm and 4cm were maintained in the still to enhance productivity of the still, sensible heat storage materials. Latent heat, porous materials were used in the still maximum evaporation rate was found for 2cm water depth 2220 ml/m^2 Maximum payback period was achieved for concentrator with sensible materials.
Key words: concentrator, solar still, Sensible, latent, porous heat storage medium, Depth Variation, heat exchanger

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1. INTRODUCTION

Solar distillation method is the cheap for producing more water. The solar stills have many advantages than other methods of desalination. Rai et al. [1990] studied the operation of still with the flat plate collector and predict the productivity decreases with the salt concentration. Badran & Tahaneih [2005] studied the effect of coupling a flat plate solar collector with the still to increase the productivity by 36% Bassam & Hamzeh [2003] have done the experimental study with different sponge cubes in basin and improves the productivity by 18% to 27.3%. Voropolulos et al. [2004] investigated the hybrid still coupled with heaters; the results showed that the productivity is doubled by coupling. Benon Bena & Fuller [2002] coupled a natural convection solar dryer with a biomass back up heater and increases four times better than the solar dryer. Nakatake [2009] increase the productivity by using external reflector in the solar still. Muafag Suleiman & Tarawneh [2007] uses sprinkler for glass cooling to reduce glass cover temperature and improves productivity of 14% more than conventional still. Senthilrajan & ramji [2018] studied different types of stills and increased productivity by coupling biomass boiler, electric heater.

2. EXPERIMENTATION

The experimental set up (Figure1) consists of the flat plate collector and concentrator. The flat plate collector unit is enclosed in a wooden box of size 0.9m^2 areas and a height of 0.54m in one end and 0.61m in another end made of G.I. sheet 4mm thick. The glass is fitted on the top of the wooden box to allow solar radiation. The thickness of the glass is 3mm. Thermocol is placed between the base surface and side walls of the tray to act as insulation materials. Heat exchanger pipe made of G.I having 25mm in diameter is fitted on the base of the basin. One end is attached to the concentrator and other end to the recirculation pipe. A measuring jar is placed outside the still to collect water from the gutter. Input tank is placed at height above the still which will supply saline water as a feed to the collector through a valve .The thermo couples are attached at the saline water storage tank, basin to measure water temperature. Thermocouple is also attached at glass surface to measure glass cover temperature saline feed. The solar radiation enters through glass surface, evaporates the water, the evaporated water reacts the bottom surface of the glass cover. Condenses and due to change of phase water vapor becomes water. The distilled water gets collected in the glass gutter from where it is collected through output tank.

The remaining brackish water is removed from still and collected at collection tank Experiments are first conducted by maintaining different water depths of 2cm, 3cm.For measuring temperatures, copper – constantan thermocouples indicator and selection switch are used. Solar radiations are measured using Kipp – Zonen Pyranometer. Wind velocity is measured by vane type digital anemometer. The beaker is used to collect and measure distilled water. This still is fabricated and tested at University College of Engineering, Ramnad, India during May 2018 to June 2018.

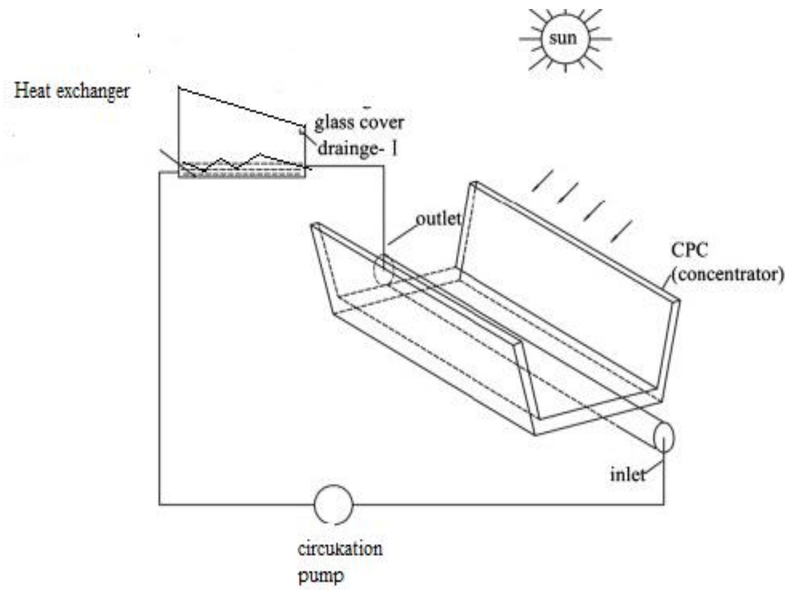

Figure1: Experimental setup

3. RESULTS AND DISCUSSION

3.1 Effect of sensible material on productivity in concentrator stills

The sensible material has the property of storing excess heat supplied into the still and helps for improving productivity from the still. The stone pieces having 25mm diameter, sand, brick pieces were put inside at various locations at the base of the stills. Experimental trials were carried out with different water depths. The results clearly stated that addition of stone pieces increases 52% for 2 cm, 47% in 3cm depth in the still other materials such as sand and brick increases42%, 34% in the still .The Figure 2 explains the effects.

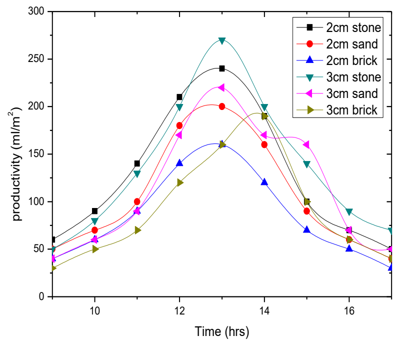

Figure 2: Effect of sensible heat materials on different water depths in reflector attached still

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www.ijiee.com Volume-01, Issue-01

3.2 Effect of latent material on productivity in concentrator stills

The latent heat materials has the property of storing excess heat supplied into the still and releases after the phase change supporting for improving water temperature in the still. The wax pieces having 30mm dimensions were put inside the small containers and kept at various locations at the base of both the stills. Trials were carried out with water and oil in the billet. The introduction of wax pieces increases 47% for 2 cm, water 33% for 2cm and oil 37% for 2cm depths in concentrator type still. The Figure 3 explains the effect of these materials.

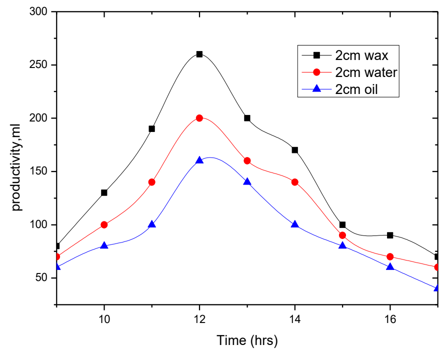

Figure 3: Effect of latent heat materials on different water depths in reflector attached still

3.3 Effect of porous material on productivity in concentrator stills

The porous materials has the property of capillarity which helps to evaporate more water from the still quickly .The wick pieces were cut in 100x70mm sizes and floated on the water .Trials were taken along with cotton, sponges. The wick pieces increases the evaporation process thus more water reaches the top of the glass and get ready for condensation. Wick increases 34% for 2 cm, sponges 28% for 2cm and cotton 21% for 2cm depths in concentrator type still. The Figure 4 explains the effect of these materials.

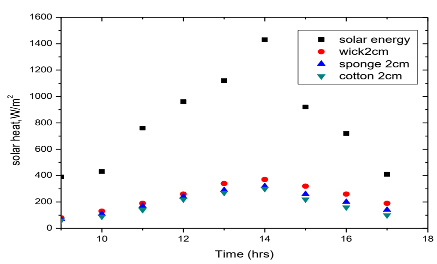

Figure.4 Effect of porous materials in reflector attached still

4. CONCLUSION

The single basin still with concentrator and heat exchanger was operated with various materials were analyzed.

The results showed that,

- The still with concentrator produces more output The output in concentrator still depend upon solar energy(radiation) which may vary from time to time.
- Concentrator requires special attention for focusing throughout the day

- Lower water depth in the still produces more output in both the stills and higher depths produces lower output.
- Introduction of sensible heat storage materials increases productivity in the stills.
- Using wax as latent heat material increases (52%)the productivity in still Porous materials increases the evaporation rate(31%). The latent heat materials increases 47% output
- The average output from concentrator type it was 3000lit/m^2/day

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