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SHORT COMMUNICATION

Enhancement of distillate output of double basin solar still with vacuum tubes

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Abstract In this research paper, attempts are made to make a double basin solar still. The overall size of the lower basin used is 1006 mm × 325 mm × 380 mm and the outer basin is 1006 mm × 536 mm × 100 mm. Black granite gravel is used to increase the distillate output by reducing the quantity of brackish or saline water in both basins. Several experiments have been conducted to determine the performance of a solar still in climate conditions of Mehsana (latitude of 23°59′ and longitude of 72° 38′), Gujarat. Here, three conditions used to determine the performance of double basin solar still like a double basin solar still alone, double basin solar still with black granite gravel, double basin solar still with vacuum tubes and double basin solar still with vacuum tubes and black granite gravel. Experimental results and comparison with other researchers show that, the daily distillate output increases by coupling vacuum tubes and by coupling vacuum tubes and black granite gravel to 56% and 65% respectively.

1. Introduction

Water is essential for all life forms on earth-plants, animals and human being, etc. For fresh water requirements humanity is dependent on rivers, ponds, lakes and underground water reservoirs. The available fresh water on earth is fixed, but the demand of fresh water is increased due to population growth and rapid industrialization. Industrial wastes and sewage discharges are mostly mixed in the rivers, so the available fresh water availability is reduced. The provision of fresh water is gradually becoming a more important issue in many areas of the world. Oceans are the only available source of large amount of water and since they contain high levels of salt, desalination of the water is necessary. Desalination is one of humankind's most primitive forms of water treatment and it is still a popular treatment solution throughout the world today. In natural desalination process solar radiation is absorbed by the sea and causes water to evaporate. The evaporated water rises above the earth's surface and moved by the wind. Once this vapour cools down to its dew point temperature, condensation occurs and the fresh water comes down as rain. The basic process is responsible for the hydrological cycle. This same principle is used in all man-made distillation systems using alternate sources of heating and cooling.

Solar still is a device, which is used for desalination purpose. Solar still is of two types namely passive solar still and

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active solar still. Generally, passive solar still employs only solar radiation to evaporate water for the production of distillate output, whereas, active solar still requires the addition of some mechanical source in the form of collector with solar energy. Hence, efficiency as well as distillate output of active solar still is good compared with passive solar still. Most of researchers, who worked on active solar still, used flat plate collector or concentrating collector with a single slope solar still. Rai and Tiwari (1983) have proved that, solar still coupled with flat plate collector increases distillate output of 24% compared with single slope single basin solar still. Tiris et al. (1998) found that coupling of flat plate collector with a solar still produces distillate output of 5 l compared with the output of 3 l from single slope solar basin solar still. Badran and Al–Tahainesh (2005) proved that, flat plate collector coupled with solar still increased efficiency of 35% compared with single slope single basin solar still in Iranian climate conditions. Dimri et al. (2008) found that, coupling a flat plate collector with higher thermal conductivity material produces higher distillate output as well as efficiency compared with single slope solar still. Voropoulus et al. (2001) connected solar pond with solar collector and solar still. They proved that coupling a solar collector and solar pond produces double productivity than passive solar still. Panchal et al. (2011) made an experiment with solar still with a flat plate collector in climate conditions of Mehsana, Gujarat. They proved 29% increase in the efficiency of solar still by coupling of flat plate. Abdel-Rahim and Lasheen (1981) made a modified design of solar still with parabolic trough focal pipe heat collector with solar still. They proved 18% increase in the efficiency of solar still. Panchal et al. (2011) made an experiment with evacuated glass tube collector with solar still in climate conditions of Mehsana, Gujarat. They found 40% increase in distillate output of solar still. Sampathkumar Karuppusamy (2012) proved that, coupling an evacuated glass tube collector with solar still increases the efficiency to 49.7%. Kargar Sharif Abad et al. (2013) integrated pulsating heat pipe with solar still. They found a remarkable increase in the rate of desalinated water production with the maximum production of 875 mL/m^2h.

The main objective of this work is to investigate experimental performance of the double basin solar with vacuum tubes. To increase distillate output of a solar still, black granite gravel is used inside the inner and outer basins of a solar still to reduce the quantity of water.

2. Procedure of experiment

Solar radiation is transmitted through toughened glass cover to the saline or brackish water in the basin. Thus, basin water gets heated and evaporated. Evaporated water particles condense on the inner side of the glass cover. The condensed water flows down the cover due to slope and reaches the distillate channel, where it collected by the flask. At the beginning of an experiment, the water level inside both basins is maintained at 4 cm. The experiment is commenced after 9 h, starting from morning 9 am to evening 5 pm with assuming steady state conditions built at every hour. Here, these hours are selected because of bright sunshine occurs during such hours. For each experiment, glass cover is cleaned to avoid dust collection on the top of glass cover of the outer basin solar still. Here, experiments have been conducted in the sunny days of March, 2012. Variables measured in the present experiments are water temperature of the outer basin (Tw1), inner glass cover temperature of the outer basin (Tgi1), water temperature of the inner basin (Tw2), inner glass cover temperature of the inner basin (Tgi2), Ambient Temperature (Ta), vacuum tube inlet temperature (Tbi), vacuum tubes outlet temperature (Tbo), solar radiation on evacuating tubes (I (t) e), solar radiation with glass cover (I (t) g) wind speed (V) and distillate output. Here, all

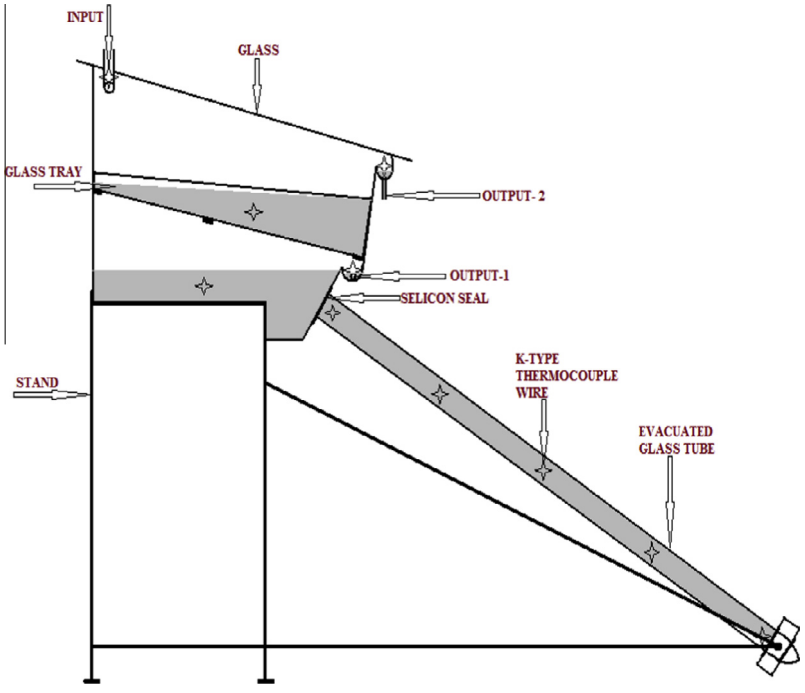

Figure 1 Experimental set up of solar still coupled with vacuum tubes.