Performance Investigation on Double Slope Solar Still

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Abstract— Solar distillation is a simple experiment of converting saline water into pure potable water. Since solar energy is a low price option, heat source from the sun is used for purification in the present work. In solar distillation, water is evaporated using the irradiation from the sun and then the evaporated water vapour is allowed to condensate as distilled water. This process eliminates salts and other impurities. In the work, double slope single basin solar still has been fabricated using the cheaply available material. In this solar still aluminium is used as a basin material. Aluminium is used because it has good thermal conductivity of 205 w/mk. An extensive study was made to evaluate the effect of water depth in the basin on the productivity of the stills. The results clearly states that the productivity of the system is inversely proportional to the water depth in the basin.

Key words: Solar Still, Solar Energy, Potable Water, Double Slop, Solar Distillation

I. Introduction

Water is a basic need of human life for various purposes. Potable water resources are generally available in the form of lakes, rivers and underground reservoirs. About 71% of the earth surface is covered with water, yet all of that 97% of the planet’s water is found in oceans, 1.65% in glaciers and the ice caps, 1.8% in ground water, and 0.0012% in the form of vapour and clouds. Less than 1.5% of all fresh water is in the available resources. Because of the growth of industries the fresh water gets affected. There are various methods are available for purifying the saline water. Distillation process is the cheaply available process for water purification.

Solar distillation is one of the most renewable method. Solar distillation is used to provide potable water or to provide water for batteries, laboratories and in hospitals. It can be used in any place because it is portable. It is also used in deserts and in brackish areas where pure water is not available. The drawback of using solar still is its productivity .The main aim is to increase the productivity.

Numerous works has gone on solar still to increase its productivity and has been published by many researchers [1][2][3][4][5][6][7]. O.O.Badran and S.Abdullah has coupled the sun tracking system to the solar still and has observed 22% increase in productivity and 2 % increase in overall efficiency [8]. K.Srithar et.al has optimized the orientation and inclination of the glass cover and has lowered the condensation loss. Also they used different materials for basin to improve heat capacity, radiation absorption capacity and to enhance the evaporation rate and they have suggested rubber as best basin material to improve absorption, storage and evaporation effects [9]. O.O.Badran has increased the productivity by 51% by using combined enhancers such as asphalt basin liner and sprinkler. He observed that the night production in the absence of solar radiation contributed to 16 % of the daily output due to the difference in temperature between the cover and water and the decrease of heat capacity [10]. Suresh.C.Ameta et al., has increased the productivity of the still by using photo catalysts. They have increased the overall efficiency of the conventional still by coating semiconducting oxides like CuO_2, PbO_2 and MnO_2 over the basin and they observed PbO_2 is most effective among all other oxides [11].

In this present work, a study is made on single basin double slope solar still to evaluate the productivity of solar still by changing the depth of water. Experiments were conducted in different water depth (1cm, 2cm, 3cm and 4cm). The results clearly states that the productivity of the solar still is inversely proportional to the water depth.

A. About Solar Energy

The sun radiates the energy uniformly in the form of electromagnetic waves in all directions. When absorbed by body, it increases its temperature. It is a clean, inexhaustible, abundantly and universally available renewable energy [13]. Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be the one of the most important supplies of energy, especially when other sources in the country have depleted. This solution is solar water distillation. It is not a new process, but it has not received the attention that it deserves. This is because it is such a low-tech and flexible solution to water problems. Nearly anyone is capable of building a still and providing with completely pure water from very questionable sources. 3.8x1024 joules of solar radiation is absorbed by earth and atmosphere per year. Solar power where sun hits atmosphere is 1017 watts and the total demand is 1013 watts. The sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require. The energy radiated by the sun on a bright sunny day is 4 to 7 Kwh per m^2 [14].

B. Principle of Solar Distillation

A basin of solar still has a thin layer of water, a transparent glass cover is placed over the basin and channel for collecting the distillate water from solar still. The glass transmits the sun rays and saline water in the basin is heated by solar radiation which passes through the glass cover. In solar still, the temperature difference between the water and glass cover is drinking force of pure water yield. It influences the rate of evaporation from the sun surface of the water within the basin flowing towards the condensing cover. Vapour flows upwards from the basin and condensate. This condensate water is collected through a PVC channel.

Measuring Instruments are pyranometer, temperature indicator, glass beaker and J type thermocouples. Pyranometer is used to measure the solar radiation and diffused radiation. Glass beaker is used to measure the pure water from the solar still. J type thermocouples are used to measure the temperature of water which is in the basin, inclined glass cover temperature.

C. Types of Solar Still

Basin Type: It consist of shallow, bracken basin of saline/impure water covered with a sloping transparent roof solar radiation that passes through the transparent roof heats the water in blackened basin. Thus evaporating water which gets condensed on the cooler under side of the glass and gets collected as distillate attached to the glass [15].

Wick Type Solar Still: It consists of a wick instead of a basin. The saline/impure water is passed through the wick or absorbed by the wick at a slow rate by capillary action. A waterproof liner is placed between the insulation and the wick. Solar energy is absorbed by the water in the wick which gets evaporated and later condensed on the underside of the glass and finally collected in the condensate channel fixed on the lower side of the bottom surface [15].

II. EXPERIMENTAL SETUP

Double slope single basin solar still was fabricated with (100 cm x 70 cm) area. In this, Aluminium is used as a basin material due to its non-corrosive nature. Aluminium sheet thickness is 2mm. It is coated with black paint for maximum absorption of solar radiation. The capacity of the basin is 40 litres. Solar power meter is used to measure solar radiation during the experiment.

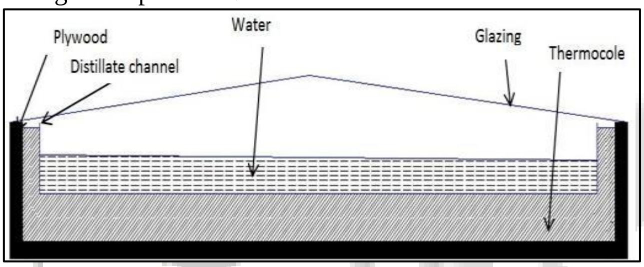

Fig. 1: Single Basin Double Slope Solar Still

Normal plain glass is used as glazing material and its thickness is 5mm. It is selected due to its transmittance of 86% and less reflectivity. It is placed inclined (12.5˚). Plywood is used as an insulating material having thickness of 2cm.It is selected because it has low thermal conductivity of 0.13 w/mk. PVC channel is used to collect pure water. Thermocole is also used as an insulating material having thickness of 1cm.

A. Details of Different Parts of the System

1) Still Basin

It is the part of the system in which the water to be distilled is kept. It is therefore essential that it must absorb solar energy. Hence it is necessary that the material have high absorbtivity or very less reflectivity and very less transmittivity.

We have used blackened Aluminium sheet (K= thermal conductivity = 205 W/mk) (2mm thick). (SIZE::100cm x 70cm).

Fig. 2: Basin of Still

2) Side Walls

It generally provides rigidness to the still. But technically it provides thermal resistance to the heat transfer that takes place from the system to the surrounding. So it must be made from the material that is having low value of thermal conductivity and should be rigid enough to sustain its own weight and the weight of the top cover.

For better insulation we have used composite wall of thermocole (inside) and wood (outside). (Size: Plywood (k= thermal conductivity=0.13 W/mk):--20mm thick, thermocole (k= thermal conductivity=0.04W/mk):--- 15 mm thick).

Fig. 3: Side Walls with Basin

3) Top Cover

The passage from where irradiation occurs on the surface of the basin is top cover. Also it is the surface where condensate collects. So the features of the top cover are: 1) Transparent to solar radiation, 2) Non-absorbent and Non-adsorbent of water, 3) Clean and smooth surface. The Materials Can Be Used Are: 1) Glass, 2) Polythene.

We have used glass (5mm) thick as top cover. Size (1.04m x 0.38m).

Fig. 4: Glass Cover

4) Channel

The condensate that is formed slides over the inclined to cover and falls in the passage, this passage which fetches out the pure water is called channel. The materials that can be used are: P.V.C., 2) G.I., 3) RPF. We have used P.V.C channel (size:: 1.1m x 0.015m).

III. RESULTS AND DISCUSSIONS

Fig. 5 shows the solar radiation from 20th February to 23rd February. During these days solar radiation is high on 22nd February. Yield is high on that day.

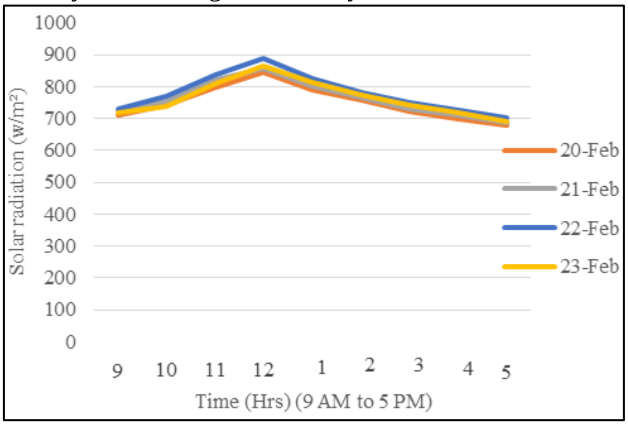

Fig. 5: Solar Radiation for Experimental Days

Fig 6. Shows the yield of single basin double slope solar still. The chart shows that production of potable water starts at 9 AM and tends to increase when time progress.

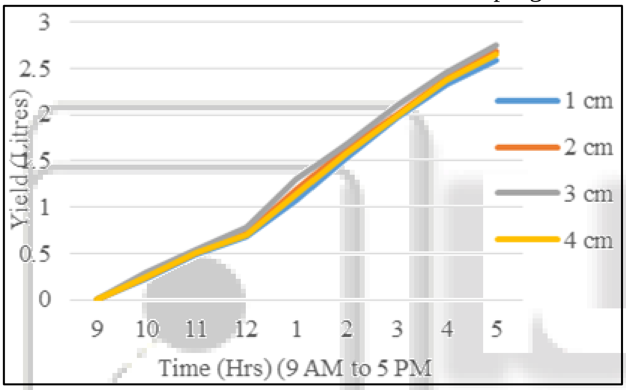

Fig. 6: Solar Still Periodic Yield

For all the depth the yield is high between 12 P.M to 1 P.M. When considering depth of 3cm yield is high. The maximum yield achieved by the solar still is 2.75 litres/day. Fig 6 shows the production of fresh water for all depth with unit interval. The yield is high between 12 P.M to 2 P.M about 1 litre.

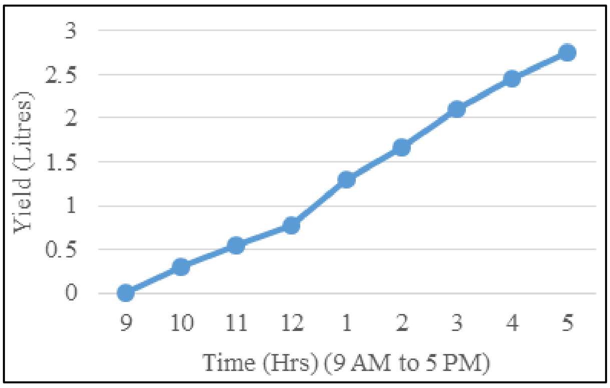

Fig. 7: Maximum Yield of Solar Still (3 cm depth)

Fig. 7 shows that the 3 cm depth yield is high. From the results it is clear that the yield of the single basin double slope solar still productivity is inversely proportional to the water depth.

IV. CONCLUSION

Double slope single basin solar still was fabricated and various tests were conducted. From the results it is concluded that,

1) The production rate is varying with changing the depth of basin.
2) Frequent maintenance also increases the productivity of the still.
3) The productivity is high at 3cm depth for this still.
4) The maximum productivity is 2.75 litres/day

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