SOLAR POWERED WATER DISTILLATION WITH CONCAVE EVAPORATION SURFACE

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Abstract - *The amount of distillate water from a solar still depends on different parameters. The evaporative surface area and glass cover temperature are the most effective parameters. Increasing the surface area or decreasing the cover temperature will enhance the distillate output. In this work, a concave type solar still with four glass cover surfaces has been studied experimentally. The main advantage of using four-glass cover surface is to increase the amount of solar radiation falling on the evaporative surface. Most of the daytime, there is a temperature difference between the four still glass sides and the evaporative surface, which allows more vapour to condensate on the lower glass cover surface. Results have shown that the average distillate productivity during the daytime is approximately 3L/m^2. It is higher than the conventional type solar still. Factors that will directly affect the build cost such as material selection, size, and simplicity overall per unit have also been evaluated. The various tests like chlorine content, total hardness, Calcium content, Electrical conductivity, TDS, pH value, were carried out in the laboratory and it was found that water obtained is safe for use. Solar distillation becomes very attractive in in-expensive long-term low technology systems especially useful where the need for small plant exists. After experimental analysis it was observed that Lake Water has more production of distilled water compared to Borewell water and River water. This research provides the growth of the small-scale industries in the village sides in India. In the set up small investment is required in first time then very less cost will appear during maintenance also.*

Key Words: Solar still, Pyramid still, Renewable energy, Desalination.

1. INTRODUCTION

Fresh water is a necessity for the sustenance of life and also the key to man's prosperity. It is generally observed that in some arid, semi-arid and coastal areas which are thinly populated and scattered, one or two family members are always busy in bringing fresh water from a long distance. In these areas solar energy is plentiful and can be used for converting saline water into distilled water. The pure water can be obtained by distillation in the simplest *solar still* generally known as the "basin type solar still".

However, various scientists have attempted to maximize the daily yield per m^2/day in a single basin solar still in a passive mode. From this work, it is been observed that the daily yield per m^2/day in the basin solar still mainly depends on the evaporative area and condensing surfaces. The objective of the present work is to study experimentally the performance of the concave type solar still at different days of the year.[1]

1.1 The Principle and Working of Solar Water Distillation

Solar stills are called stills because they distill or purify water. Solar radiation passes through the cover and is absorbed and converted into heat in the black surface. Impure water in the basin or concave surface is heated and the vapour produced is condensed to purified water on the cooler interior of the glass. The transparent glass transmits nearly all radiation falling on it and absorbs very little; hence it remains cool enough to condense the water vapour. The condensed water slows down the sloping roof and is collected in bottles provided at the bottom. Saline water can be replaced in the operation by either continuous operation or by batches. Although there are numerous configurations of basin type units, their basic theory is identical. The concave basin type solar still has produced distilled water at a cost per unit of product lower than other types of solar equipment.

The production rate of solar still depends primarily on the amount of solar radiation available but is affected by several other factors; like ambient air temperature, sky conditions etc., the effect of design parameters such as orientation of still, single sloped or double sloped, inclination of glass cover, insulation of the base etc., and the effect of operating parameters such as water depth in the basin or the concave surface, absorption emittance properties of still, preheating of water etc.[2]

1.2 Experimental setup

A concave type solar still is designed and constructed for the purpose of experimental work. Figure 1.1 shows a photograph of the solar still. The basin of the solar still is a concave with a diameter of 55cms. The bottom and sides of the basin are insulated by 10 cm thickness glass wool surrounded by a wood 2 cm thickness. The basin depth of concave surface is 23 cm. The copper basin surface is coated black to absorb maximum solar radiations. The four sides of glass cover are of ordinary window glass of 4 mm thickness with a tilt angle of 45 degrees to the horizontal surface. The distillate water is collected by a aluminum channel fixed on the sides at the lower end of the glass cover and is taken out through a pneumatic pipe to two slight plastic bottles as shown in the figure. The whole system is made vapour tight using silicone rubber as a sealant to prevent any vapour leakage.[3]

The experimental setup is suitably instrumented to measure the temperatures at different points of the still, total solar radiation and the amount of distillate. The temperatures have been measured using K-type thermocouple wires which are connected to a digital temperature indicator. Solar radiation intensity is measured instantaneously by recording the short circuit D.C. current of a calibrated solar cell using a Pyranometer (solar mappy).

Figure 1.1: A photograph of the experimental solar still

Table -1.1: Specification of Solar Still

Sl.No	Component	Material	Number required.
1	Outer Box	Plywood (3/4' sheet)	1
2	Inner Box	Plywood (3/4' sheet)	1
3	Copper Basin	Copper	1
4	Glass	Normal	4
5	Tank	G I Tin	1
6	Inlet Pipe	Rubber tubes	1
7	Drain Pipe	Rubber tubes	1
8	Distilled water receiver pipe	Pneumatic tubes	2
9	Distilled water container	Plastic bottles	2
10	Thermocouples	K-Type	6 m
11	Temperature indicator	-	1
12	Solar mappy	-	1

The main components of solar still are:

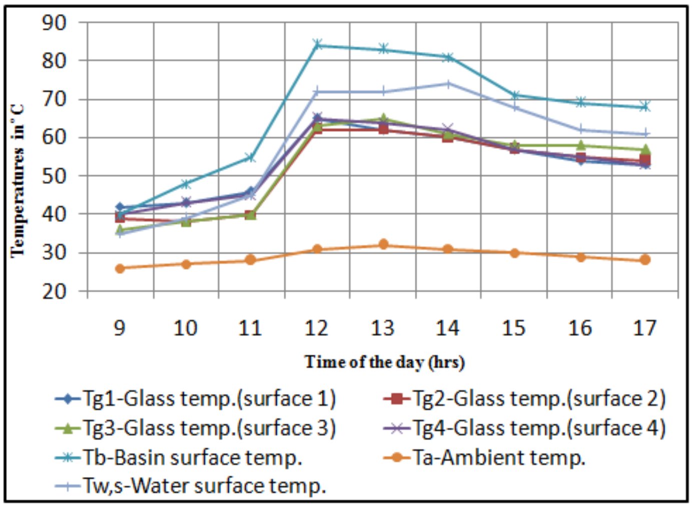
1. Outer box
2. Inner box
3. Copper basin
4. Normal glass

2. RESULTS AND DISCUSSIONS

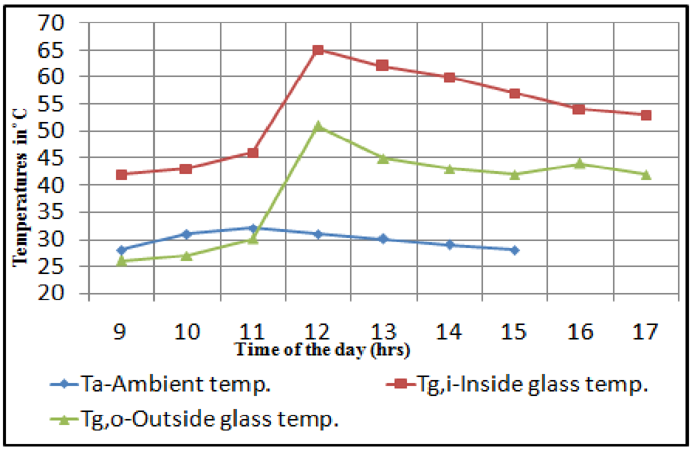
Experiments have been carried out on the test rig for bore well water, river water & lake water for a water depth of 30 mm, the Borewell water was collected from K.L.E.I.T., Hubballi, Lake water from Unkal Lake and the River water was collected from Mallaprabha River near Gokak. The temperature variation of the components, variation of fresh water productivity, accumulated fresh water per day and the efficiency of the solar still, rate of evaporation and rate of heat transfer under case study is presented and illustrated in graphs from 2.1 to 2.6.

According to the hourly variation of the solar radiation, for the solar desalination systems at dates from Apr 5th to May 11th the results have been illustrated. The variation of the ambient temperature T_a, and inner glass cover temperatures T_g, are varied and have peak values around the noon interval (12:00-3.30). The hourly variation of the basin water temperatures T_w, and ambient temperature T_a, are plotted. It is noticed, as time goes on, all temperatures increase and begin to decrease after 4:00 pm with respect to the variation of the solar radiation.[4]

The experimental data presented in the following analysis is chosen for some clear sky days as the example for Lake water. The hourly temperature variation of the four glass sides, basin water, surface and ambient air temperatures during the daytime is as shown in Graph 2.1. It can be observed that the temperatures at all points increase with time till maximum value at about 13-hour afternoon and then decrease again.

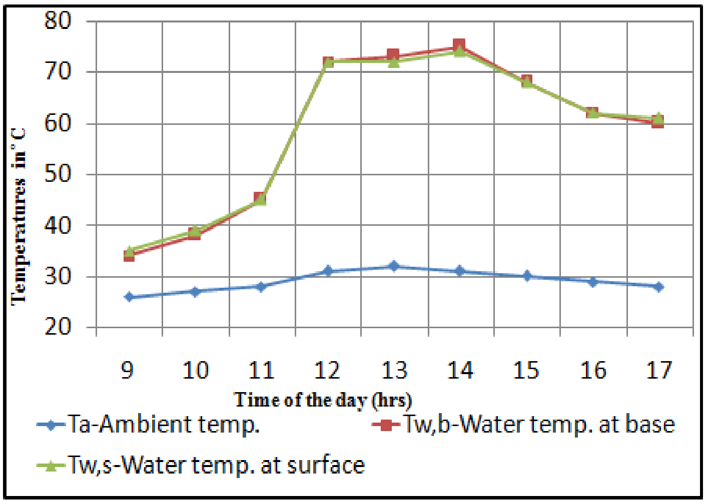


Graph 2.1: Hourly variation of temperatures during the day



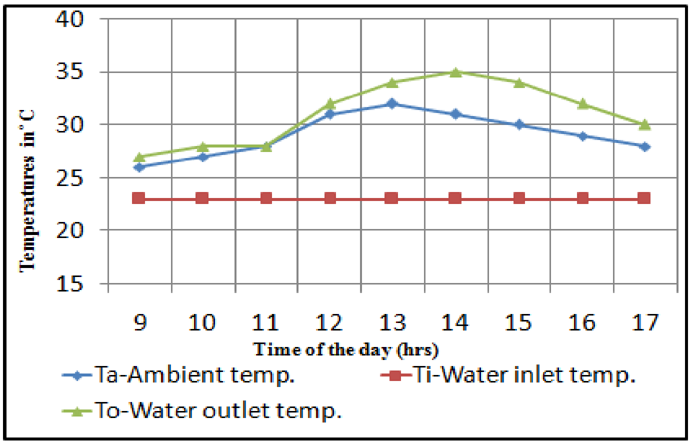
Graph 2.2: Temperature v/s Time

The Graph 2.2 shows the hourly temperature variation of the inside glass temperature, ambient temperature and outside glass temperature with respect to time of the day for the Lake water. It is observed that inside glass temperature is more compared to outside glass temperature. It is also observed that the temperature at all points increases with time, the maximum value obtained is between 12 to 3 pm and then starts to decrease late in the afternoon.



Graph 2.3: Temperature v/s Time

The Graph 2.3 shows the hourly temperature variation of the Distillation unit water base temperature, water surface temperature and ambient temperature for the Lake water. It is observed that base water temperature is more compared to surface water temperature. It is also observed that the temperature at all points increases with time, the maximum value obtained is between 12 to 3 pm and then starts to decrease late in the afternoon.



Graph 2.4: Temperature v/s Time

The Graph 2.4 shows the hourly temperature variation of the Distillation unit inlet water temperature, outlet water temperature and ambient temperature for the Lake water. It is observed that outlet water temperature is more compared to inlet water temperature. It is also observed that the temperature at all points increases with time, the maximum value is between 12 to 3 pm and start to decrease late in the afternoon.

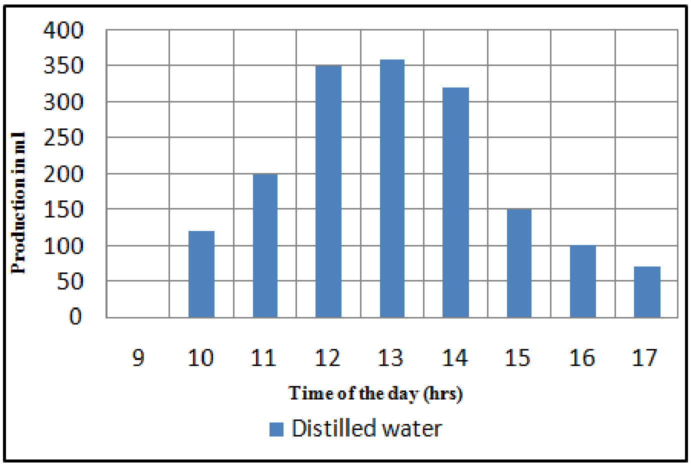
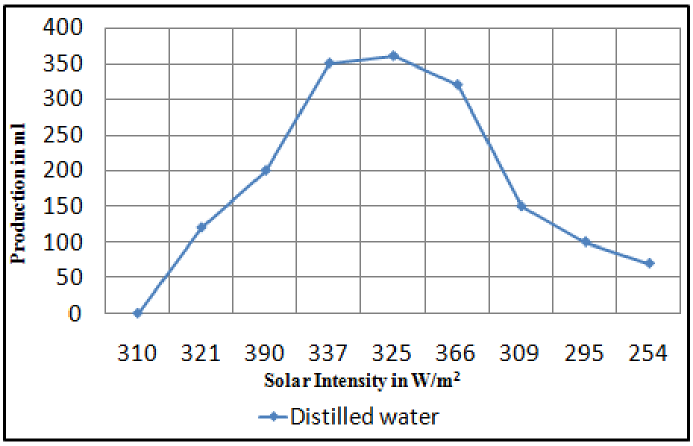


Chart 2.1: Variation of accumulated distilled water during the day

The Chart 2.1 shows the hourly variation of distilled water production for Distillation unit. It is observed that distilled water production is more between 12 to 3 pm and then starts to decrease late in the afternoon for Lake water.



Graph 2.6: Production v/s solar intensity

The Graph 2.6 shows the hourly variation of distilled water production for distillation unit. It is observed that distilled water production increases as the solar intensity increases and then starts to decrease late in the afternoon for Lake water.

Similar analysis have also been carried out for River water and Borewell water and results have been discussed considering all the three samples of water.

3. CONCLUSIONS

Based on the results obtained from the experimental work, the following can be concluded:

1. The temperature of the four glass cover surface is not equally specially till afternoon.
2. The average distillate productivity of the proposed still during the 8 hours time is about 1.5 L/m^2.
3. It was observed that River Water has more production of distilled water compared to River water and Borewell water.

Distilled water is very useful water in industries house and technical College and any under graduate college in workshop, Chemistry lab or for inverter battery. So this research will provide the facility in the village also general people can setup small equipment on the roof of the building and get distill water continuous basis. This research will provide the growth of the small scale industries in the village side in India. In the set up small investment required in first time then very less lost will appear in maintenance also.

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BIOGRAPHIES

Presently working as Assistant Professor in Department of Mechanical Engineering, K.L.E.I.T, Hubballi. Completed M-Tech in Thermal Engineering and has experience of 4 years

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