Experimental Investigation on Effective Copper Conduction Path Thickness for Multilayer Absorber Plate Type Solar Still

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Abstract- Solar still is a best alternative solution against most of the conventional water distillation system. The multilayer absorber plate type solar still is the more effective technique to enhance the passive solar still productivity. The experiment has been carried out to find out the best thickness of copper conduction path for the multilayer absorber plate type solar still. The results have concluded that the productivity of solar still is reduced with increasing the conduction path thickness and water depth. The maximum productivity of distilled water has been produced in the multilayer absorber type solar still with 0.5cm thick copper conduction path and 1cm water depth.

Keywords- *Multilayer absorber plate, solar still, solar radiation, Glass cover, Multi effect.*

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1. Introduction

Distillation is an oldest technique to distillate brackish or salty water in to potable water. Various technologies were invented for desalination from time to time and it has been accepted by people without knowing future environmental consequences. Many developed countries have given utmost priority to rural water supply in their development plans. Distillation of brackish or saline water, wherever it is available, is a good method to obtain fresh water. However, the conventional distillation processes such as Multi-effect evaporation, Multi stage flash evaporation, thin film distillation, reverse osmosis and electrolysis are energy intensive techniques, and are the feasible for large stage water demands. The alternative solution of this problem is solar distillation system and a device which works on solar energy to distillate the water is called solar still. Solar still is very simple to construct, but due to its low productivity and efficiency it is not popularly used in the market. Solar still is working on solar light which is free of cost but it required more space. Its material is easily available in the market and it cannot require a higher skill for the maintenance. To increase the simple solar still efficiency so many works are done. Compared to passive solar still active solar still productivity is higher.

1.1 Solar Still

The basin of the solar still has been packed with briny water and the solar rays are passing through the glass cover to heat the water in the blackened internal surface of basin and as a result of temperature difference between water and glass inner surfaces water gets evaporated. As the water inside the solar still evaporates, it leaves all microbes and contaminates in a basin. The pure water vapour will condensate on the internal side of the glass runs through the minor side of the still and then gets collected in a closed container which is used as potable water.

There are many solar stills were developed in years by using the basic principle of solar still in the world. A lot of works has been done on solar still; on this work solar still is divided in two parts: (i) simple (passive) solar still, (ii) active solar still.

In a simple (passive) solar still, the solar radiation is received directly by the basin water and is the only source of energy to increasing the water temperature and consequently, the evaporation leading to a lower output. This is the major drawback of a passive solar still.

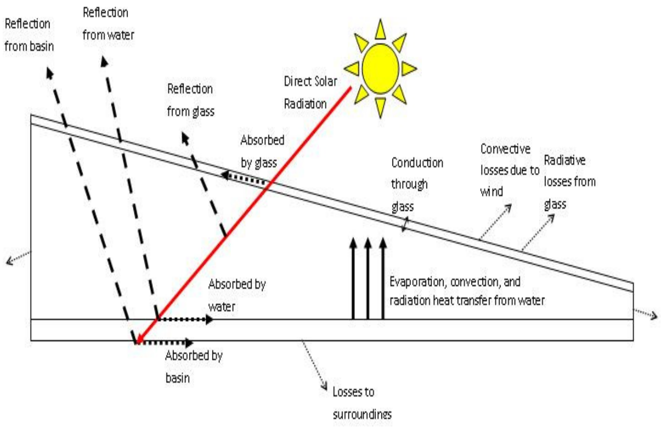

Figure 1 Simple solar still [3]

Later, in order to resolve the problem of poorer productivity, many research work will go on or done on the conventional (passive) solar still and active solar still. This review extends to Comparative Study to optimize the height for conduction path of multilayer absorber type solar still.

1.2 Improvements in Passive Solar Still

- **Improvements of Cover plate of Solar Still**

The cover plate supports at the top of the solar still to receive the radiations of the sun and directed to the basin to evaporate the water. So if enhancement is done in cover plate so due to incident of maximum radiation, output of solar still is improved.

- **Improvements in Basin of Solar Still**

Basin of solar still is a case in which briny water is stored on which solar radiations are incident and briny water is transformed in to potable water. It should have good absorptance but minimum Reflectance.

1.3 Problem Definition

Necessitate the Enhancement in the output of a Solar still and reduction in the required Area of basin. Because of lower Productivity as well as Efficiency of the Solar Still, it is not used commercially. Improvement in the performance f multilayer absorber type solar still is required.

1.4 Methodology

This research study has been carried out to enhance the productivity of the multilayer absorber plate type solar still. For the batter comparison two same size of solar stills will designed and fabricating. The separate absorber plates have been made at different height of conduction path. For more precise result the experimental setup exposed to the sun light towards North direction. In this research study depth of water (1.5cm, 2cm, 2.5cm, 2cm) and height (0.5cm, 1cm, 1.5cm) of conduction path is varying and absorber plates are inserted in to the two solar stills simultaneously one after one. Record the instantaneous data of the temperatures, solar radiation, and productive output. Analyze the results from the experimental data and conclude the same.

2. Passive Solar Distillation System

Our main focus is to improve the solar still efficiency. The numerous parameters are affecting the performance of the still such as material of the basin, wind velocity, water depth, and absorber area in the basin, solar radiation, ambient temperature, inclination angle and type of collector used. The productivity of any type of solar still is determined by temperature difference between inner surface of glass cover and surface of water.

Palak Patel et al. reported multilayer absorber plate type solar still with comparative study with and without multilayer absorber plate in passive solar still. They observed that in both the cases day productivity decreasing and night productivity increasing with increasing the water depth in solar still. The day and night productivity of multilayer absorber solar still increasing by 3.9% and 28.94% at 0.5 cm water depth, 4.9% and 29.06% by 1 cm water depth, 5% and 40% by 1.5 cm water depth, 5.2% and 40.38% by 2 cm water depth respectively.

Hiroshi Tanaka et al. work on theoretical analysis of basin type solar still with flat plate external bottom reflector extending from the front wall of the still in addition to the internal (two sides and back walls) reflector is presented and analyzed theoretically on three days (the spring equinox and summer and winter solstices) at 30°N latitude. They proposed a geometrical model to calculate the direct solar radiation reflected by the external bottom reflector and then absorbed onto the basin liner and also performed a numerical analysis of heat and mass transfer in the still. They found that the external reflector can reflect the sun rays to the basin liner and increase distillate productivity. The daily amount of distillate of the still with internal and external bottom reflector is predicted to be 41%, 25% and 62% greater than that of a conventional basin type still on the spring equinox and summer and winter solstices, respectively, by setting the external reflector's inclination to the proper values according to the seasons when the glass cover's inclination angle is fixed at 20° from horizontal and the length of the external reflector is the same as the length of the basin liner. [5]

Sangeeta Suneja, G.N. Tiwari works on transient analysis of a double basin solar still. They derived explicit expressions for the temperatures of various components of the inverted absorber double basin solar still and its efficiency. The effect of water depth in the lower basin on the performance of the system has been investigated comprehensively. For enunciation of the analytical results, numerical calculations have been made using meteorological parameters for a typical winter day in Delhi. It has been observed that the daily yield of an inverted absorber double basin solar still increases with the increase of water depth in the lower basin for a given water mass in the upper basin. [6]

Sangeeta Suneja, G.N. Tlwari, S.N. Rai Presented an analysis of an inverted absorber double-effect solar still. Energy balance equations have been written, and analytical expressions for water and condensing cover temperatures and the hourly yield have been derived. Numerical computations have been carried out for a typical day in Delhi. The results thus obtained have been compared with those of the conventional double effect (double basin) solar still. It was observed that an inverted absorber solar still gives a higher output than the conventional double-effect one. [7]

3. Experimental Setup

Figure 2 Experimental setup

Experimental setup of solar still has been made of galvanized iron sheet to reducing the corrosion effect. Assumed 23⁰ inclination of condensing glass cover to receive the maximum solar radiation and inner surface of the basin is painted black to absorb the maximum solar radiation. Scale marking up to 5cm on the larger side wall of the basin. Bottom side of the basin is insulated with the thermocol sheet to reducing the heat loss from bottom. 1liter capacity bottle has been connected with flexible pipe at the collection channel outlet to collect the drinking water from the solar still.

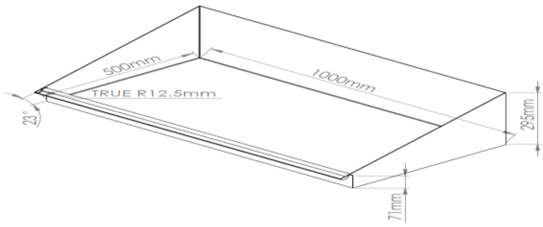

Figure 3 Designed solar still three dimensional measurement view

Four different temperature sensors J-type has been connected to the basin, first is immersed into the water inside the basin to measure the temperature of water inside the basin, second is fixed at the centre of the basin to measure the vapor temperature inside the basin, third is fixed on to the inner surface of the glass cover to measure the inside temperature of glass cover, forth is fixed below the solar still to measure the atmospheric air temperature for both the basin. Thermal tape has been used to seal glass cover and basin joint to make the basin air tight. The solar still is directly exposed to the sunlight towards south.

3.1 Experimental procedure:

Before the experiment started first check the sensor calibration. To check the sensor accuracy available seventeen thermocouple sensors immersed into the insulated water bath. Then observe the temperature data in the temperature scanner and pick the seven temperature sensors which are indicating the equal appropriate data in the temperature scanner.

The temperature sensors fixed in both the solar still and exposed to the sunlight towards south direction facing. Filling both the solar stills with brackish water and measuring the TDS of inlet water. Both solar stills are sealed with the help of thermal tape and make it air tight. Hourly data of temperatures, solar radiation, and output of drinking water has been measured. Solar stills have been filled with water as per predefined observations 1.5cm, 2cm, and 2.5cm. The absorber plates in the solar stills have been changed according to the observations such as 0.5cm & 1cm copper conduction path, and 1.5cm & 1cm copper conduction path. After collecting the data the calculation will be carried out as per energy balance equations.

4. Result and Discussion

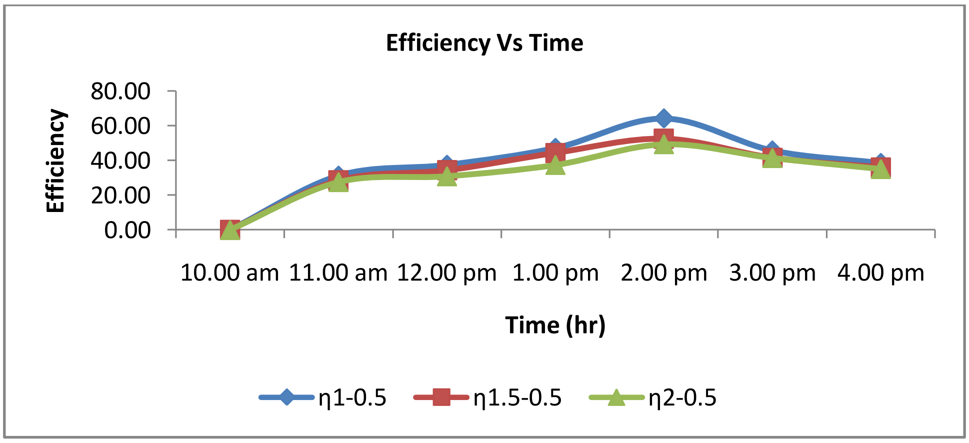

Figure 4 Efficiency of the solar stills vs Time

 ISSN: 2454-4248
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Figure 4 shows the effect on efficiency with respect to time. The maximum efficiency of the solar stills has been observed during the 2:00pm of the pick hours. The maximum efficiency observed in the 0.5cm copper conduction path solar still with 1cm water depth during the pick hours of the day.

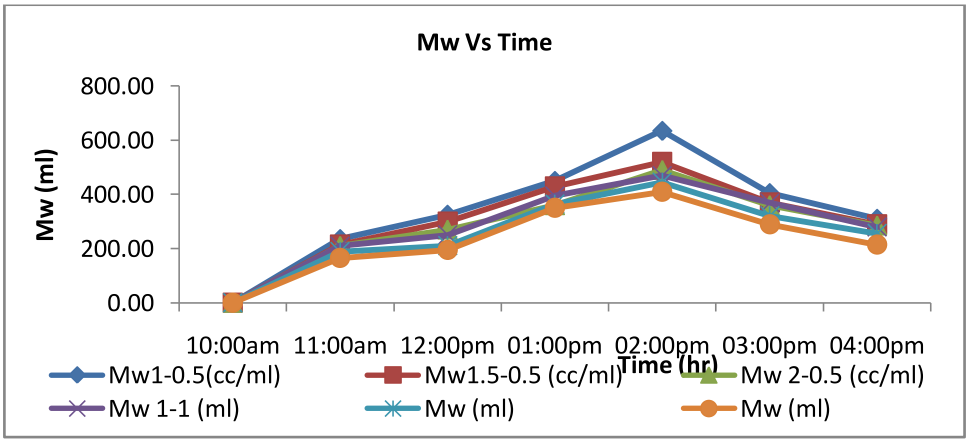

Figure 5 Mass of distilled water collected by the solar stills

Figure 5 shows the effect on Mass of distilled water collected with respect to time. The maximum distilled water of the solar stills has been collected in the 0.5cm copper conduction path solar still with 1cm water depth. The maximum efficiency observed in the 0.5cm copper conduction path solar still with 1cm water depth during the pick hours of the day.

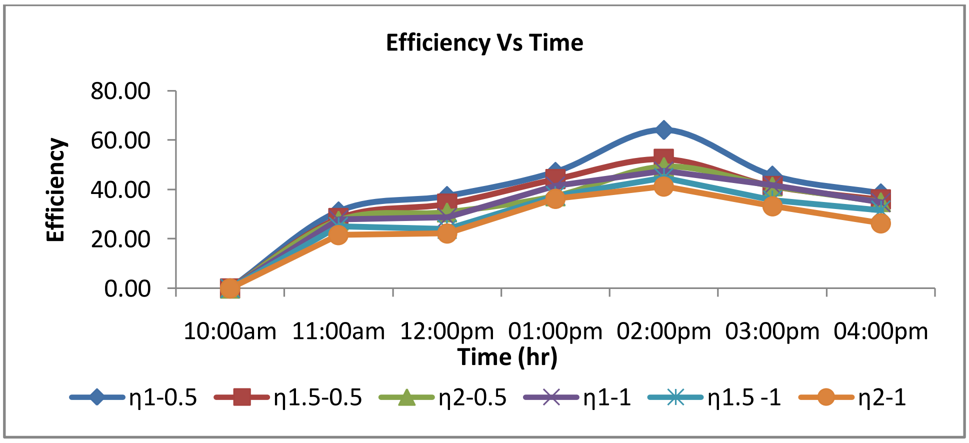

Figure 6 Efficiency of the solar stills Vs Time

Figure 6 shows the effect on efficiency with respect to time. The maximum efficiency of the solar stills has been observed during the 2:00pm of the pick hours. The maximum efficiency observed in the 0.5cm copper conduction path solar still with 1cm water depth during the pick hours of the day.

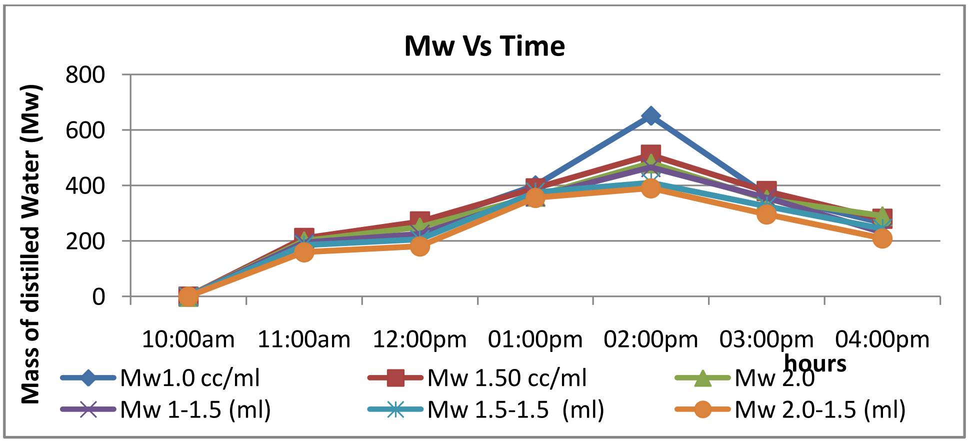

Figure 7 Mass of distilled water collected by the solar stills

Figure 7 shows the effect on Mass of distilled water collected with respect to time. The maximum distilled water of the solar stills has been collected in the 0.5cm copper conduction path solar still with 1cm water depth. The maximum efficiency observed in the 0.5cm copper conduction path solar still with 1cm water depth during the pick hours of the day.

Conclusion

From the observation table and results it has been conclude that the copper conduction path with 0.5cm thickness is more effective than the 1cm and 1.5cm thickness. The maximum value of the distilled water is achieved in the 0.5cm thick conduction path solar still and also the maximum efficiency observed in it.

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