



Enhanced Performance of Design of a Single Basin Solar Still made up of Copper

KEYWORDS

Solar Still, Distillate, Solar Radiation, Still Efficiency

M. Koilraj Gnanadason

Research Scholar, Department of Mechanical Engineering, PRIST University, Thanjavur, Tamilnadu, India

G Hariharan

Research Scholar, Anna University, Tuticorin Campus, Tamilnadu, India

P. Senthil Kumar

Professor and Head, Dept. of Mechanical Engineering, KSR College of Engineering, Tiruchengode, Tamilnadu, India

ABSTRACT As the available fresh water is finite on earth, its demand is increasing day by day. The distillation is one of the important methods of getting potable water from brackish and sea water using the free energy supply from the sun. The problem of solar stills is the low productivity. In this context, an experimental work is conducted on a single slope solar still in which the still basin was built with copper sheet. The rate of heat transfer to water in the still made up of Copper is more and hence the increase in the water temperature and productivity. The attempts are also made to increase the productivity of water by painting black coating inside the Copper still basin. The theoretical results agree well with the experimental ones.

I. INTRODUCTION

Water has been recognized as a basic human right. There is a severe shortage of fresh water in the world today. The increasing world population growth together with increasing industrial and agricultural activities all over the world contributes to the depletion and pollution of fresh water resources. The rapid increasing need for energy and environmental concerns has focused much attention on renewable energy resources [1]. Water is an abundant natural resource that covers three quarters of the earth's surface. However, around 97% of the water in the world is in the ocean, only about 3% of all water sources are potable. Less than 1% fresh water is available within human reach and even this small fraction (ground water, lakes and rivers) is believed to be adequate to support life and vegetation on the earth and the rest is permanent snow cover, ice and permafrost in polar region [2]. Large quantities of fresh water are required in many parts of the world for agricultural, industrial and domestic uses. The utilization of renewable energy offers a wide range of exceptional benefits and expected to have a flourishing future and an important role in the domain of brackish and seawater desalination in developing countries [3]. Fortunately, the regions in most need of additional fresh water are those with the most intense solar radiation. For this reason thermal solar energy in desalination processes should be the most promising application of renewable energies to seawater desalination [4]. The salinity of brackish water varies with locations. In such cases, fresh water has to be either transported for long distances or connected with an expensive distribution water network at extremely high cost for a small population [5]. Excess brackishness causes the problem of taste, stomach problems and laxative effects. According to World Health Organization (WHO), the permissible limit of salinity in water is 500 ppm but most of the water available on earth has the salinity up to 10,000 ppm. Many solar distillation systems were developed over the years using the above principle for water purification in many parts of the world like reverse osmosis, electro dialysis, vapour compression, multistage flash distillation, multiple-effect distillation and solar distillation, which are used for purification of water [6]. Among the non-conventional methods to desalinate brackish water or seawater, the cheapest method is solar distillation. The yield of the single basin solar still is very less and it increases considerably when the solar still was built with copper sheet. They greatly improve the rate of evaporation and the rate of condensation on the cooler surface [7]. The efficiency is higher for solar still made up of copper sheet and it can be increased further

by providing a heat absorbing materials inside the still. This cost-effective design is expected to provide the rural communities an efficient way to convert the brackish water in to potable water. Different techniques were used to enhance the output of the stills. The distilled water evaporation rate is improved by designing the still basin on Copper sheet instead of Galvanized Iron sheet.

II. EXPERIMENTAL SETUP

A solar still operates similar to the natural hydrologic cycle of evaporation and condensation. In the conventional solar still, saline water is stored in the basin of still, and the sun rays are passed through the glass cover to heat the water in the basin and the water gets evaporated and it leaves all contaminants and microbes in the basin. The purified water vapour condenses on the inner side of the glass, runs through the lower side of the still and then gets collected. In this context, a single basin solar still of same size 900x300x50mm and 2 mm thick made up of Copper sheet was fabricated by sheet metal work of bending and cutting. The shallow rectangular basin made up of Copper sheet, was placed inside the outer box. The outer box made by plywood. Thermo cool of 2.5 cm thickness with thermal conductivity of 0.045W/mK is used as an insulating material to reduce the heat losses from the bottom and the side walls of the solar still. The bottom of the basin is usually painted black to absorb the sun's heat which in turn increases the evaporation rate. The top of the basin is covered with a glass of 5 mm thick. The glass has been mounted at an angle of 9° equal to the latitude of Nazareth, to ensure maximum transmission of solar radiation into the still as well as enabling condensed vapor to trickle down the trough built in the still basin. Provision is made to supply water to the still and to collect the condensate from the still. The edges of the glass are sealed so that the entire basin becomes air tight. Iron – Constantan J type Thermocouples were installed to measure the glass cover temperature, the vapour temperature, the water temperature and the ambient temperature. Solarimeter is used to measure the solar intensity. The wind speed is measured by an Anemometer. A still basin made up of Copper, painted black at the inside bottom is fabricated for the same specifications as shown in the Fig. 1. The Copper has higher thermal conductivity of 401 W/mK which is comparatively higher than G.I. Sheet. Therefore, the rate of heat transfer to water in the still is more. Thus the water temperature will be increased. Due to this evaporation rate of water will also be increased. The Still outer box of size 1050 X 350 X 430mm made up of Plywood (Water Proof)

because of low cost and availability. Still basin of size 900x300x50 made up of Copper Sheet because of its high thermal conductivity.



Fig. 1 Solar Still made up of Copper

III. EXPERIMENTAL ANALYSIS FOR SOLAR STILL MADE UP OF COPPER SHEET

A single basin solar still made up of copper sheet inside bottom black colour coated was fabricated and tested from 7:00 am to 7:00 pm during the months of April and May 2012. The same measurement processes is repeated to study the effect of each parameter on the still productivity for various operating conditions. The wind speed is found to be around 2-4 m/s. The average daily output was found to be 3 liters/day for basin area of 0.27 m² based on data. The optimized glass cover angle was 9°. The water level in the solar basin is maintained to a level of 1cm and 0% salt concentration. The hour by hour reading is tabulated in the below tabular column Table I. The productivity rate varies as time passes from the early morning until late afternoon and the output of the solar still varies directly with the ambient temperature. The hourly output is maximum in the afternoon hours when the ambient the ambient temperature is at its daily peak.

TABLE I
GI SHEET Vs COPPER SOLAR STILL (1Cm WATER LEVEL 0% SALT CONCENTRATION)

Time Duration	DBT	WBT	Wind Velocity	Solar Intensity	Water Collection in ml
Hour	°C	°C	m/s	W/m ²	Copper Still
07a.m-08a.m	28	25	0.9	850	50
08a.m-09a.m	30	26	1	1000	80
09a.m-10a.m	32	27	1	1250	120
10a.m-11a.m	34	27	0.7	1275	200
11a.m-12a.m	35	28	4.5	340	260
12p.m-13p.m	36	27	0.5	1143	300
13p.m-14p.m	37	27	2.1	1060	330
14p.m-15p.m	36.5	28	1.8	338	380
15p.m-16p.m	36	27	2.5	750	320
16p.m-17p.m	33	25	2.3	1100	240
17p.m-18p.m	31	24	2.5	904	130
18p.m-19p.m	28	23	2.0	700	80

A. Measurements

The measurements of the temperatures, solar radiation intensity, and the production of distilled water are taken hourly to study the effect of each parameter on the still productivity. In this study various operating conditions have been examined such as; different water depth, insulation thickness, ambient temperature and salt concentrations. The total productivity and solar Intensity for each day are also measured. Also, different experimental tests are carried out at different ambient conditions. The wind speed is found to be around 2-4 m/s.

In this still, the productivity increases because copper conducts more heat. If the level of salt concentration is higher, the portion of incident solar radiation is wasted for heating the salt rather than heat the water inside the still. So that water temperature inside the basin is decreased and in turn the amount of water evaporated is lowered. Therefore, more the salt concentrations lower the distillate collected. The water temperature has a direct effect on the productivity whereas the depth of water increases from 1 cm to 3 cm and 5 cm, the daily still output decreases i.e. inversely proportional. The efficiency was calculated as 80 % higher when compared with the stills being used worldwide. The Copper has higher thermal conductivity and it conducts more heat. The annual yield is at its maximum when the condensing glass cover inclination is equal to the latitude of the place.

IV. RESULTS & DISCUSSION

1) Productivity Vs Time with various Concentrations: For a solar still made up of copper sheet, Graph drawn for Productivity and Time for various concentrations of 0 %, 10 % and 20% for the depth of water level of 1cm. It reveals an increase in the productivity for minimum depths of water level as shown in Fig. 2 and it will decrease with increase in water level. It also shows that the lower the salt concentrations the higher will be the productivity.

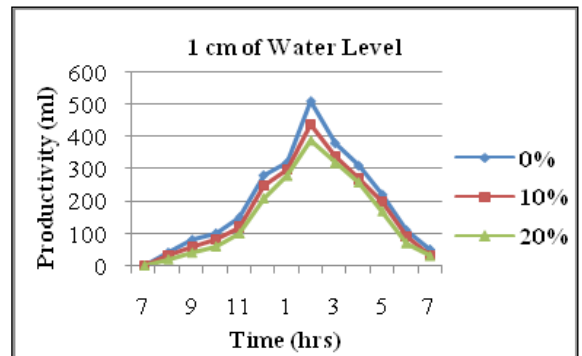


Fig. 2 Productivity Vs Time

2) Productivity Vs Time with different levels of water: For a solar still made up of copper sheet, Graphs are drawn for Productivity and Time for salt concentration of 0 % and where different depths of water level of 1cm, 3 cm and 5 cm as shown in Fig. 3. It reveals an increase in the productivity for minimum depths of water level. It also shows that the higher the salt concentrations the will be lower the productivity.

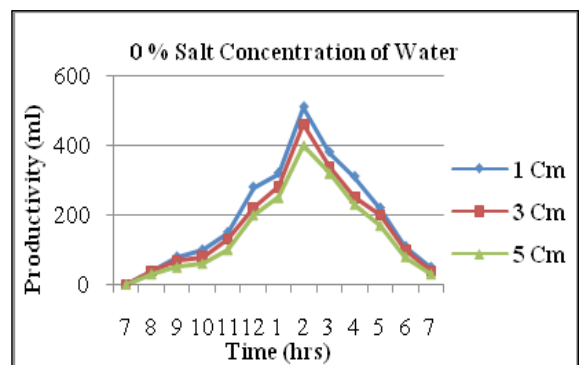


Fig. 3 Productivity Vs Time

V. CONCLUSION

In this innovative copper still the productivity is improved significantly as Copper has higher thermal conductivity and it conducts more heat to the water in the basin. The solar radiation is also absorbed by black paint coated inside bottom of the basin and thus increases the temperature of the

water.. Due to the increase in heat gain for vaporization of water inside the still, the amount of distillate collected in this still is higher (2490 ml/day) and hence the increase in efficiency by 80 %. The water temperature has a direct effect on the productivity. There is an increase in the productivity for the minimum depths of water level. Therefore more the salt

concentrations lower the distillate collected. Hence, there is a decrease in efficiency of the still for the incident solar radiation. The overall cost of the experimental setup is Rs.8900. The payback period for both the stills is less than 1 Year. Thus the efficiency of a solar still is improved by modified design of the still basin made with copper sheet.

REFERENCE

- [1] Bhanu Pratap Singh, "Performance Evaluation of a Integrated Single Slope Solar Still With Solar Water Heater," MIT International Journal of Mechanical Engineering, Vol. 1, No. 1, pp 68-71, Jan 2011. | [2] Omar O. Badran, Mazen M. Abu-khader, "Evaluating thermal performance of a single slope solar still," Heat And Mass Transfer, No.43, pp. 985-995, 2007. | [3] Srithar, K. "Performance Analysis of Vapour Adsorption Solar Still Integrated with Mini-solar Pond for Effluent Treatment," International Journal of Chemical Engineering and Applications, Vol. 1, No. 4, December 2010. | [4] Al Hayek I and Bardan O O, "The effect of using different designs of solar stills on water distillation," Desalination, No.150, pp.230-250, 2004. | [5] Salah Abdallah, Omar Badran, Mazen M, Abu-Khader, "Performance evaluation of a modified design of a single-basin solar still, Desalination, No.219, pp.222-230, 2008. | [6] Tiwari G.N, H.N. Singh, Rajesh Tripathy, "Present status of solar distillation," solar energy, No. 75, pp.367-373, 2003. | [7] Kalidasa Murugavel K, Chockelingam Kn KSK, Srithar K, "Progresses in improve the effectiveness of the single basin passive solar still," Desalination, No. 220, pp., 677-686, 2008. |

