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Performance of Masonic Solar Still with Box Type Internal Condenser in Summer Climate

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ABSTRACT

Solar Desalination via Solar still is the best method of obtaining 2-3 liter of potable water in a typical summer day from brackish water. Solar still in its state of art is 'Rain Machine' or 'Hydrological Cycle in trapezoidal basin.' In analysis of solar still, it has been proved and well accepted that, rate of condensation is strong function of temperature difference between inner glass cover (condensing cover) and basin water temperature. In architecture and working of Masonic solar still, it is found that, temperature difference is not conducive for condensation in summer days and at peak Sun shines hours. Literature review and opinion of expertise suggest advent of internal condenser in solar still. Among different configurations box type copper metal make internal condenser is fabricated and fixed at back wall of still. Water is fed to box from overhead tank so as to get natural siphoning and cooling effect inside the still. Operating parameter namely depth of water in basin is kept in 5 to 10 mm for various reading across days of April and May. The hourly yield during peak Sun shines hours i.e. from 12 to 3 pm is measured and found in order of 180-250ml.This performance of solar still match performance of Fiber Reinforced Plastic (FRP) still. Overall temperature mapping of still confirms suitability of internal condenser and its substantial effect on rate of condensation. The maximum temperature in still has crossed value of 50ºC and helped in getting overnight yield in two fold proportions as compared to winter climate without condenser.

Keywords— Hourly Yield, Box Type Internal condenser, Masonic Solar Still, Temperature Difference

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I. INTRODUCTION

Water is the primary source of life and it is essential to life. Next to oxygen, fresh water is the most important substance for sustaining human life, and it's a key for life. Water shortage is a worldwide problem, where 40% of the world population is suffering from water scarcity. Although 75 percent of the earth is covered with water, 97 % of Earth's water is too salty for us to use. 3% of Earth's water is fresh water; only one third is accessible at the lakes and rivers. So the fact that 97% of the earth's surface is covered with saline water has been an important catalyst for developing water desalination technologies.

Potable water demand is increasing due to rapid population increase and also due to uncontrolled pollution of the fresh water resources. The fresh water crisis is already evident in many parts of India, varying scale and intensity at different times of the year. The use of solar energy is more economical than the use of fossil fuel in remote areas having low population densities, low rain fall and abundant available solar energy. The average daily solar radiation varies between 4 and 7 kWh per square meter for different

parts of the country. There are on an average 250-300 clear sunny days in a year and it receives about 5000 trillion kWh of solar energy in a year.

The conventional desalination technologies like multistage flash, multi-effect, vapor compression, iron exchange, reverse osmosis, electrolysis are expensive for the production of small amount of fresh water, also use of conventional energy sources has a negative impact of the environment. Interest in the simple solar still has been developed due to its simple design, construction, and low operating and maintenance cost, mainly in remote areas. However its low productivity stimulated the development of methods to increase its efficiency.

Husham M. Ahmed and Khalid A. Alfayalkawy,[10] have studied the effect of wind speed water sprinkler on outer surface of condensing glass and conclude that 1.increasing the wind speed from 1.2 m/s (the average measured wind speed), to 3 m/s and to 4.5 m/s (the average values were taken) has the effect of increasing the still productivity by 8% and 15.5 % respectively. 2. Cooling down the outside glass cover of the solar still using water sprinklers for 30 seconds and at 20 minute intervals increases the stills productivity by 15.7%. Decreasing the interval to 10 minutes, increase the stills productivity to 31.8%. SamirkhanMalek et.al.,[13]have studied the effect of using external condenser on the performance of solar still and observed that modified solar still has been more effective as compared to conventional solar still and it gives the higher productivity as compared to conventional solar still. A.Rai, N. Singh and V, sachan[11] have studied effect of water cooling of glass cover of solar still and observed that, The average daily productivity of the still was 1.424 kg without glass cover cooling and 1.667 kg with cooling of the glass cover. The effect of film cooling on the thermal efficiency of solar still was also studied. It is observed that the thermal efficiency of the still is improved by 4%. SampathKumar et.al.,[1] have studied the performance of the single basin solar still augmented with evacuated tubes and inferred that the daily production rate of the solar still is increased by 49.7% and increased by 59.48% by using black stones incorporated with evacuated tubes. B. Selva Kumar et.al, 2008[2] made thermal performance of a “V” type solar still with a charcoal absorber is analyzed and distilled water collection output is estimated. The internal heat transfer and external heat transfer modes are studied. The efficiency of the still is estimated using four ways. The overall efficiency of the still is 24.47% without charcoal, 30.05% with charcoal, 11.92% with boosting mirror and 14.11% with boosting mirror and charcoal.

Hence number of attempts was made to increase productivity of solar still to give more amount distillate water by accelerating principle processes in solar still like evaporation and condensation. Hence modifications needed to accelerate the principle processes are either within the solar still or outside of solar still or both inside and outside of solar still. Techniques used for increasing evaporation rate are using reflectors, changing glass cover inclination, orientation of basin, using additives in the basin like charcoal, dyes, nano fluids etc. some of techniques such as using water sprinkler, blower, cooling tubes are used to cool the glass cover and increase the condensation rate, also using internal condenser temperature of wall get decreased and raises the condensation rate.

A. PRINCIPLE OF WORKING

A solar still operates on the basic principles of evaporation and condensation. The impure saline water into solar still and Sun’s ray penetrate a glass surface causing the water to heat up through the greenhouse effect and consequently, evaporate. When the water evaporated inside the solar still, it leaves all contaminants and microbes behind the basin. The evaporated water condenses on the underside of the glass and runs into a collection through and then into an enclosed container. Condensation in solar still is strong function of basin water temperature and temperature difference between basin and inner glass temperature among other operating parameters of still viz. death of water, wind velocity etc.

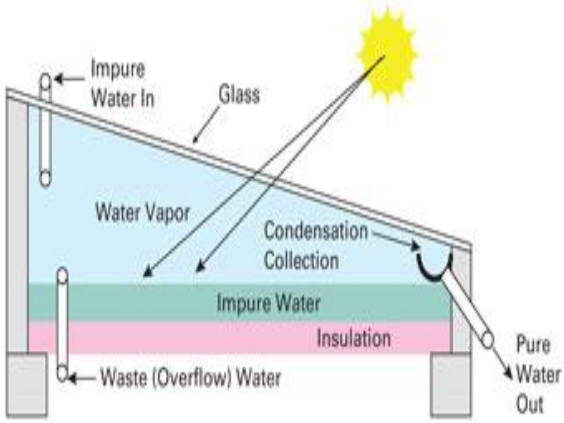

Fig. 1 Schematic of Conventional Single Basin Solar Still

II. EXPERIMENTAL SETUP

Fig. 2 Actual Set Up of Masonic Solar Still

Experimental set up consist of single basinwith effective area of 1 m^2. The still is made of bricks, sands, Cement etc. Inner surfaces of still are made insulated by using tiles. To absorb maximum solar energy, internal area of still is covered with black resin. It has a top cover of transparent glass of 4 mm thickness, 105×110 cm of surface area and inclination of 18.5° to horizontal. The low thickness of glass transmits up to 98% of solar radiation. Aluminum channels

are fitted on all sides of still. On the back side wall of Masonic solar still the copper box is fitted.Thedimensions of box are 12'×36' (inch) thickness of 0.75' (inch). Cooling water carrying capacity of copper box is 7-8 liters. There are two openings provided to copper box for supplying the cooling water to the box. The continuous water supply has been provided to the copper box through the overhead water tank. The temperature difference between box water and tank water and potential energy of tank water provides force for natural circulation. The whole assembly is made air tight. Condensate water flowing through is collected outside the solar still in plastic bottle through the pipe inserted sidewise. Here we use digital multipoint temperature indicator for measuring the different temperatures inside the still. We measure the different temperatures inside still and condensate collected on hourly basis only at peak hours. Eight channel thermocouples are used for measuring the different temperature i.e. basin water temperature (Tw), inner glass temperature (Tv).Copper box temperature (T2).

A. OBSERVATION TABLE

TABLE I

Date	Tw	Tv	T2	$\dot{M}_1$	$\dot{M}_2$
	48	47	41	180	150
	49	47	42	200	180
15-04-15	48	46	44	160	150
	50	49	41	210	200
	53	50	45	225	225
16-04-15	51	51	47	250	255
	49	48	42	190	125
	50	47	42	250	200
17-04-15	50	48	45	210	180
	49	46	42	190	180
	50	47	42	200	190
18-04-15	49	47	44	215	210
	49	48	42	210	175
	53	47	43	200	190
19-04-15	51	47	46	170	160
	48	47	42	180	140
	50	47	43	200	170
20-04-15	49	48	46	210	200

III.RESULT & DISCUSSION

In the summer conditions temperature of basin is high, hence evaporation rate of water is also high .Elevated temperature conditions in still decreases the condensation rate because temperature gap for conducive condensation decreases. Hence for increasing temperature gap and condensation rate, copper box is used and experiment is done in May 2015. The experiments have been conducted from 12.00a.m. To 3.00p.m. During 15th May to 18th May only during the critical hours where temperatures range is higher. It has been observed that if basin temperature of still is higher, amount of distilled water is more. An average hourly yield during peak Sun shines hours i.e. from 12 to 3 pm is measured and found in order of 180-250ml which is much higher(22-25%more) as compared to solar still without condenser copper box which gives 150-200 ml per hour (Ref.Table No.1). This performance of solar still matches the performance of Fiber Reinforced Plastic (FRP) still. Overall temperature mapping of still confirms suitability of internal condenser and its substantial effect on rate of condensation. The maximum temperature in still has crossed value of 50ºC and helped in getting overnight yield in two fold proportions as compared to winter climate and without condenser.

A. NOMENCLATURES

Tw - Average basin temperature in ^{0}C

Tv – Inner glass temperature in ^{0}C

T2 – Copper box temperature in ^{0}C

$\dot{M}_1$ – Experimental amount of distilled water (yield) in ml

$\dot{M}_2$ – Experimental amount of distillate water in ml without condenser.

IV.CONCLUSION

Using copper box as an internal condenser,condensation rate of solar still increases. All times of operations box temperature is lowest among all temperatures. In further part, Spalding theory of mass transfer can be exploited, rather it gives an opportunity for validation and development of new correlation.

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REFERENCES

[1] S. Nijmeh, S. Odeh, B. Akash, Experimental and theoretical study of a single-basin solar still in Jordan, *International Communications in Heat and Mass Transfer* 32 (2005) 565–572

[2] B. Selva Kumara, Sanjay Kumar, R. Jayaprakasha, Performance analysis of a "V" type solar still using a charcoal absorber and a boosting mirror, Desalination 229 (2008) 217–230

[3] Hitesh N Panchal1, Manish Doshi, PrakashChavda, RanvirgiriGoswami, *international journal of applied engineering research*, dindigul, Volume 1, No 4, 2011

[4] G.N. Tiwari, S.K. Shukla and I.P Singh, Computer Modeling of Passive/Active Solar Stills by Using Inner Glass Temperature", Desalination, 154, (2003), 171-185